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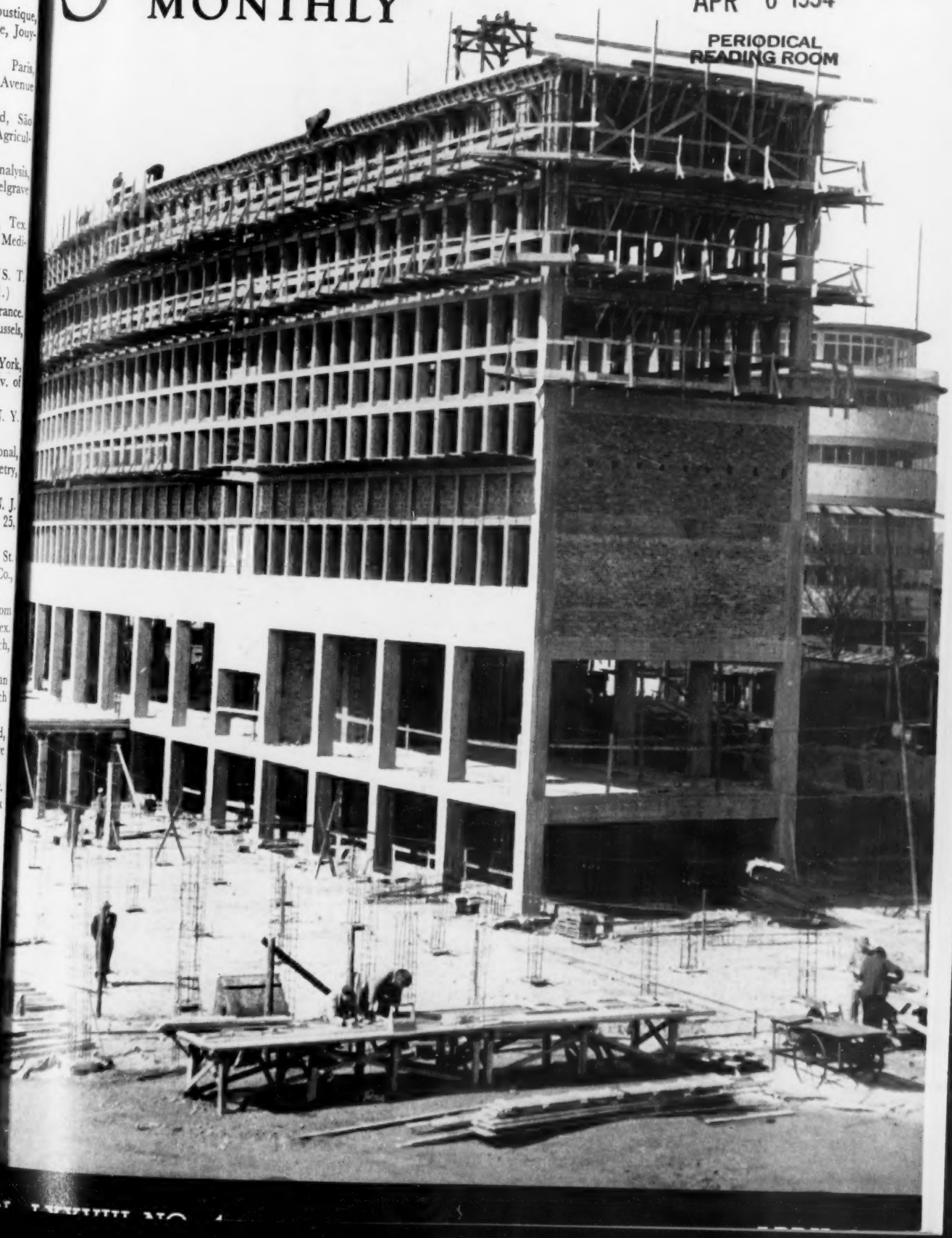

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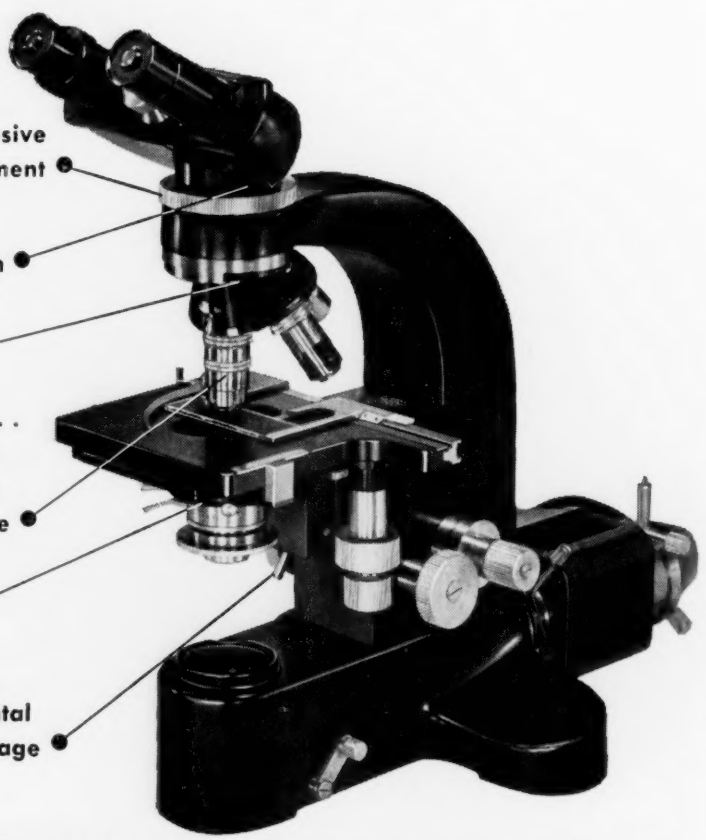

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THE SCIENTIFIC MONTHLY

VOL. LXXVIII APRIL 1954 NO. 4

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Science and Technology

(From the Month's News Releases)

Geiger Counter

A new, thin, glass-wall-jacketed Geiger counter is available. This counter is ideal for monitoring radioactivity where processes involving continuous flow are involved. The operation threshold is 800 to 1000 volts. Window thickness is 30 mg/cm². (M. G. Tait, Radiation Counter Laboratories, Inc., Dept. PF-12, SM, 5122 West Grove St., Skokie, Ill.)

Count-O-Matic Scaler

A complete laboratory unit, designed for precise automatic measurements of radioactivity, supplies the necessary operating voltages for an external Geiger or scintillation counter, counts the nuclear disintegrations detected by the counter, and measures the length of time required to accumulate a predetermined number of these disintegrations. (Nuclear Instrument and Chemical Corporation, Dept. SM, 223 W. Erie St., Chicago 10, Ill.)

Reflectogage

A portable, ultrasonic instrument measures the thickness of steel sheet (from .014 to .400) where only one surface is available, checks the continuity of bonds, and tests raw stock for laminar defects. All manual controls are grouped according to function on the front panel which also contains the viewing screen. (Sperry Products, Inc., Dept. SM, Danbury, Conn.)

Signal Generator

A new signal generator (Fig. 1) provides decade selection of 9000 predetermined, crystal-controlled frequencies, in 100 cy/sec steps over the range from 100 kilocycles to one megacycle.

Engineered for applications requiring a signal source of high stability and accuracy, the generator's functional electrical and mechanical design permits instant selection of any desired frequency in its range. (Decade Instrument Company, Dept. SM, Box 153, Caldwell, N. J.)

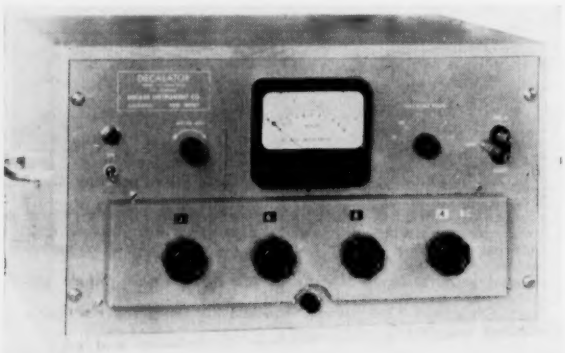

FIG. 1

Stopcock

An improved line of stopcocks, featuring a new spring type clamp, replaces the old style rubber washer and improves stopcock performance by further reducing the possibility of leakage. The clamp snaps readily into the groove in the end of the stopcock plug and prevents its working loose by maintaining a constant pressure against the shell. (Corning Glass Works, Dept. SM, Corning, N. Y.)

Walk-In Incubator

A walk-in incubator has been designed to provide more efficient use-per-unit-space for biochemical, bacteriological, pharmaceutical, biological, food, water, and cosmetic research and control laboratories as well as overcrowded hospital laboratories. Its 4′ × 4′ inside floor area and 7′ height provides 57 running feet of shelf space. (Fisher Scientific Company, Dept. SM, 717 Forbes St., Pittsburgh 19, Pa.)

Venetian Blind Cleaner

A new labor-saving device cleans venetian blind slats without the necessity of taking down the blinds. The device carries the cleaning fluid in a self-contained reservoir. It cleans and polishes both sides of the slat in one operation and will not soil tapes. (The Blind-Eze Co., Dept. SM, 690 Lincoln Rd., Otsego, Mich.)

Radioisotope Counter-Holder

A mobile, adjustable radioisotope counter-holder provides a safe, convenient support for the counter and shield used in measurements of radioactivity. It is particularly useful in determination of I-131 uptake by the thyroid gland. The unit is readily adjustable, and the holder will fit either scintillation or Geiger counters. (M. G. Tait, Radiation Counter Laboratories, Inc., Dept. SM, 5122 West Grove St., Skokie, Ill.)

Plastic "Glass"

Plastic "glass" for protecting woods and metals against the weather can be brushed or sprayed on and will dry in 30 min. to a crystal-clear finish. It resists discoloration, cracking, and oxidation. (Surface Engineering Co., Inc., Dept. SM, 1535–39 Barwise Ave., Wichita 1, Kansas.)

Plastic Molding Machine

A plastic molding machine incorporates recent engineering advancements in automatic injection molding. It is of horizontal construction with four tie rods equipped with micrometer adjusting nuts for even distribution of pressure on four points of toggle clamp and for fast mold set-up. The clamp is designed with a relief valve, so if a part is not ejected the machine shuts down with-

out damaging the mold. (Moslo Machinery Co., Dept. SM, 2443 Prospect Ave., Cleveland 15, Ohio.)

Eye Sweep

The eye sweep unit facilitates removal of foreign bodies from the eye. One end is fitted with a magnet for removing steel splinters, while the other is fitted with a flexible loop for removing cinders, dust, and other particles. Sterilization of the instrument will not diminish the magnetic qualities nor affect the loop. (General Scientific Equipment Co., Dept. SM, 2700 W. Huntingdon St., Philadelphia 32, Pa.)

Glass Lathe

A new type of glass lathe that meets a broad range of glassworking requirements in the laboratory has been developed. A sleeve-grip chuck permits quick set-ups of practically all forms of glass work without elaborate accessories. Tubing of any length up to 100 mm. diameter can be mounted through the spindle. (Bethlehem Apparatus Company, Inc., Dept. SM, Front and Depot Sts., Hellertown, Pa.)

Sensitive Pressure Transducer

A sensitive instrument for the measurement of differential pressure in terms of electrical output is available. The range of working fluids encompasses all noncorrosive gases and liquids, and the design allows a selection of working ranges from ±0.5 to ±15 psi differential at line pressures up to 100 psi. The instrument will withstand the application of maximum line pressure in either direction. (North American Instruments, Inc., Dept. SM, 2420 N. Lake Ave., Altadena, Calif.)

Electrostatic Air Cleaner

A new ceiling-suspended model of the home electrostatic air cleaner has been designed. The unit, which can easily be installed in the main return air duct of a forced-air heating system, removes 90 percent of all air-borne dust and pollen and is effective against tobacco smoke particles. (Westinghouse Electric Corporation, Dept. T-556, SM, 200 Readville St., Hyde Park, Boston 36, Mass.)

Glass Instruments Washer

Now available is an improved glass instruments washer with a new series of glassware baskets. Everything from over-sized graduates to micropipettes can be accommodated, including large, odd-shapped funnels and flasks that are not usually handled by mechanical washers. (Fisher Scientific Company, Dept. SM, 717 Forbes St., Pittsburgh 19, Pa.)

Plastic Inserts for Lock Nuts

The combined attack of fuming nitric acid, operational shock, and vibration and thermal cycling can't loosen the grip of lock nuts fitted with new plastic inserts. Sub-zero to 165° F variations of temperature, sustained engine vibrations, and exposure to moisture (or water immersion) will not effect the stability of the plastic inserts. (M. W. Kellogg Company, Dept. SM, P. O. Box 469, Jersey City 3, N. J.)

Environment-Proof Switches

A new series of environment-proof switches has been designed for use in exposed locations in aircraft. They feature a hermetically sealed, split-contact switching unit enclosed in an alumnium housing. Their performance remains constant regardless of changes in atmospheric conditions. The switches may also be mounted near fuel tanks without danger of igniting escaping gases or liquids. (Minneapolis-Honeywell Regulator Company, Dept. SM, 2753 Fourth Ave. South, Minneapolis 8, Minn.)

Micro-Viewscope

A new micro-viewscope (Fig. 2) combines in one unit a microscope with 75× and 500× magnification with enclosed illuminating and projection elements that render a brilliant image on an 8″ ground glass screen on a sloping desk. A mechanical stage gives precision control for centering or scanning details of a slide; and the unit is also equipped for photomicrography. (William J. Hacker & Co., Inc., Dept. SM, 82 Beaver St., New York 5.)

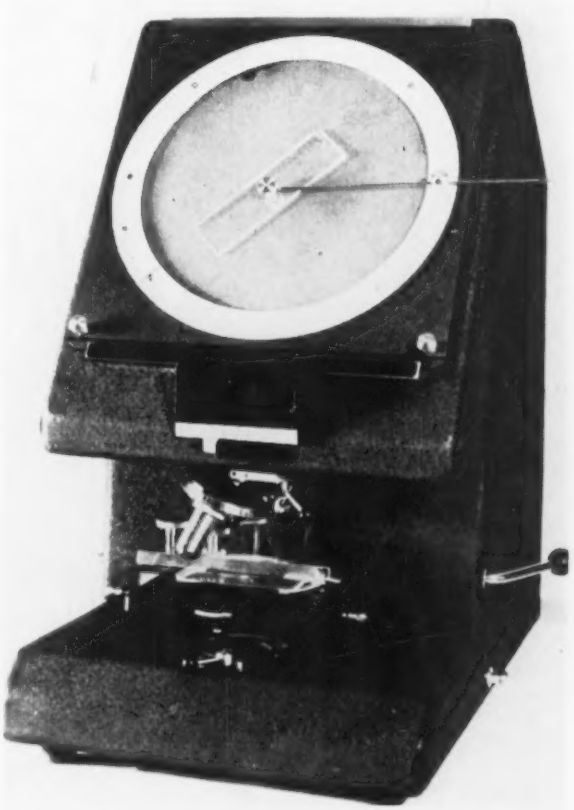

FIG. 2

Shock Prevention Disc

A small, chemically-treated, felt disc, wiped on automobile seat covers, gives protection from static shock. It dries quickly, is fully guaranteed, and is harmless to all fabrics and finishes. (Braun Laboratories, Dept. SM, 206 S. Hutchinson St., Philadelphia 7, Pa.)

Level Indicator

Accidental overfilling or emptying of bins, silos, tanks, and other storage units can now be prevented automatically by an electronic signal device. The new instrument uses a radio signal to indicate and control the level of stored material. (Hewitt-Robins Incorporated, Dept. SM, Stamford, Conn.)

Varistor Experimental Kits

Two new varistor kits provide a variety of miniature disk-type and rod-type varistors for experimental applications in electronics, communications, power control, and allied industries. General Electric, Dept. SM, Schenectady 5, N. Y.)

Scintillator

A new scintillator (Fig. 3) will define the limits of an oil field and eliminate the need for drilling many dry holes. It will also locate uranium deposits and has many uses in a scientific laboratory. The new scintillator can be operated from an aircraft or a moving vehicle. (Precision Radiation Instruments, Inc., Dept. SM, 2235 So. La Brea Ave., Los Angeles 16.)

FIG. 3

Spectrophotometer

A spectrophotometer, intended for testing solutions by the well-known spectrophotometric procedures, will be of interest to analysts and educators who have been unable to take advantage of the speed and accuracy of the spectrophotometer due to the high cost of equipment. The operation is simple in that there are no knobs to turn or switches to operate after setting zero absorbance with a blank. The test solution absorbance is directly indicated by the meter. (Harold Kruger Instruments, Dept. SM, P. O. Box 164, San Gabriel, Calif.)

Volt-Ammeter

A new alternating current volt-ammeter is capable of performing over the entire audio range with laboratory-standard accuracy. Multi-range measurements can be made at frequencies from 20 to 20,000 cycles to an accuracy of .05 percent or better. The volt-ammeter is designed to be independent of frequency so that the a. c. voltages or currents can be measured over wide ranges. (Baldwin and Mermey, Dept. SM, 205 East 42nd St., New York 17.)

Colored Recording Tape

New uses for recording tape, particularly for professional and educational purposes, are expected to grow out of the development of colored tapes, now available in green and blue as well as the standard clear plastic base. Plastic reels in a choice of five colors can also be supplied. (Auto Devices, Inc., Dept. SM, 444 Madison Ave., New York 17.)

Serological Baths

A series of uniform-temperature serological baths has a temperature control closer than ± 0.4° C. yet base and walls are free of heating elements and stirrers. Racks are carried side-by-side. The screwdriver adjustment on the thermostat prevents accidental moving of the setting. An aluminum "eye-lid" shield protects the control panel from splashes. (Fisher-Scientific Company, Dept. SM, 717 Forbes St., Pittsburgh 19.)

Miniature Torque Wrench

A tiny torque wrench, like the larger tools used industrially to tighten bolts to the exact degree, measures up to 80 inch grams of torque. Other models measure up to 8 and 16 inch ounces and are designed for use in the electronics, instrument, and precision equipment fields. (P. A. Sturtevant Co., Dept. SM, Addison, Ill.)

Autoclaving Paper Wrapper

A disposable, non-disintegrating paper wrapper for autoclaving is designed for use by pharmaceutical manufacturers, hospitals, and industrial laboratories to wrap glassware, gloves, bandages, and other equipment to be sterilized. (Robert Busse & Co., Inc., Dept. SM, 111 Broad St., New York 4.)

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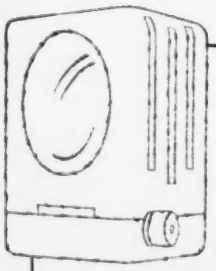

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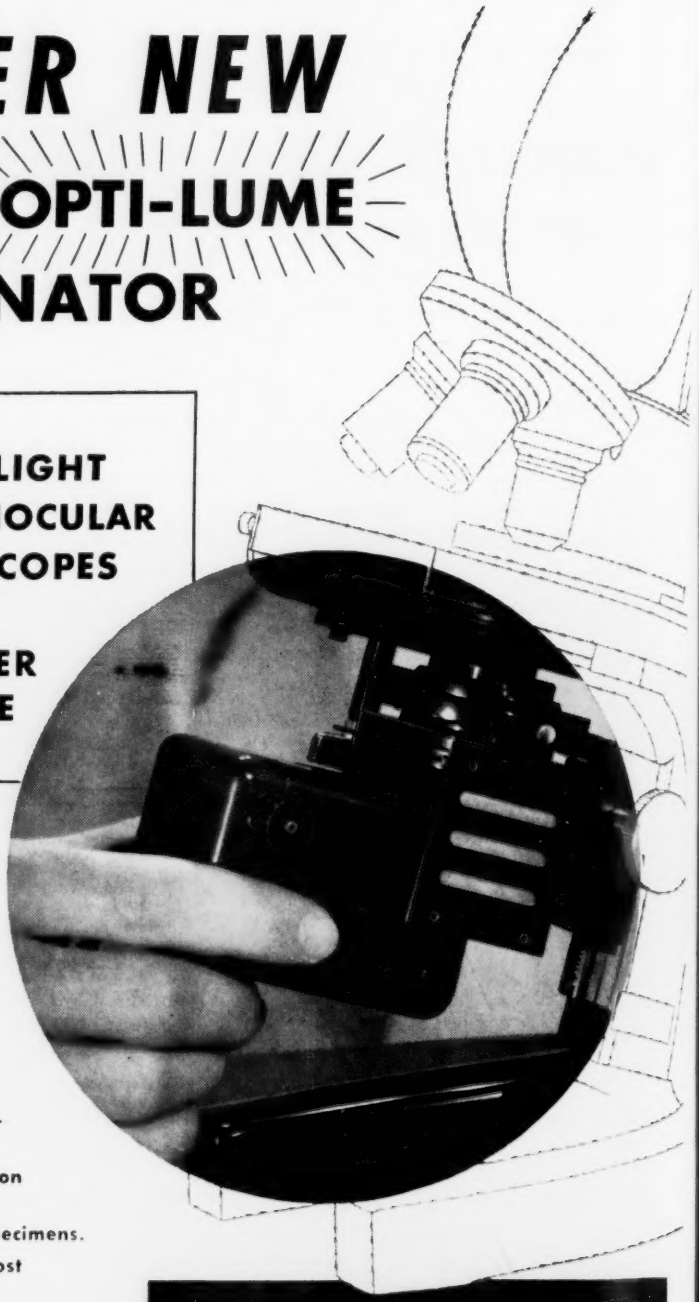

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THE
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APRIL 1954

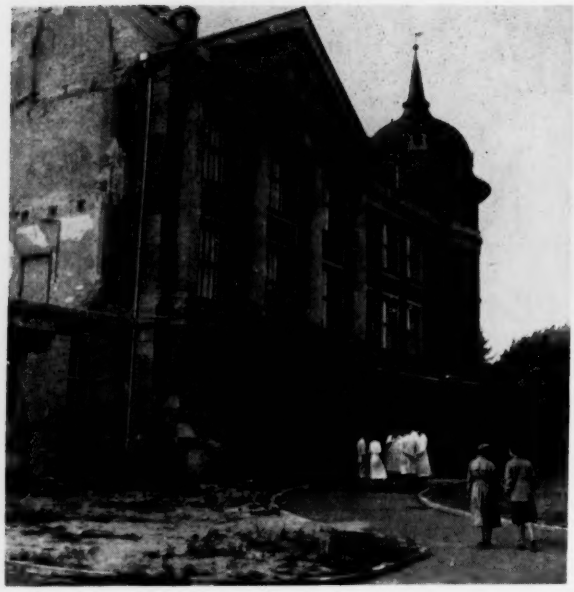
New Stirrings in German Universities

OTTO F. KRAUSHAAR

Dr. Kraushaar, president of Goucher College and former professor of philosophy at Smith College, is well known as a lecturer on education and public affairs. He received his A.B. and A.M. degrees from the State University of Iowa and his Ph.D. from Harvard University. During World War II, Dr. Kraushaar organized the Middle East branch of the U.S. Armed Forces Institute and planned and supervised Army educational activities in the Middle East, Iran, Iraq, and Africa. He also planned and organized the Army's post-hostilities educational program in the Pacific. The following article is the result of a visit to German universities in the American West Zone made in the spring of 1953.

THE resounding victory of Dr. Konrad Adenauer in the recent German elections was a tonic of reassurance for those who refused to believe that our policy in Germany was quite as futile and misguided as the critics and Cassandras made it seem. Although we have learned by now that things are seldom as bad or as good as they first seem to excited partisans, the election provided tangible proof that the policy of German unification and European integration, sponsored by the United States, has met with more general approval in Germany than we had supposed, while the bond of the German people with the West proved to be stronger than we had dared believe. It would be foolish, to be sure, in accounting for the outcome, to overestimate the strength of farsighted international sentiment and not give due weight to the power of Dr. Adenauer's personal prestige, the appreciation of the Germans regarding which side of their bread is buttered, the desire to rearm stemming from national pride and deep-rooted military traditions, and other reasons of national interest. But however one may appraise these factors, there is no doubt that the West has won an invaluable extension of time and with it a climate of opinion more favorable to the growth of those influences that the free countries have striven to exert in helping the Germans to shape their destiny in a new European order. For the German problem is the problem of Europe, even as it is one of the two major problems of the world.

It is a little over eight years now since Germany lay bleeding and beaten under the total victory of allied arms, and her economic, political, social, and intellectual institutions, wasted by Nazidom, lay in utter ruin. Today the visitor cannot fail to be impressed by the phenomenal revival of West German industry and trade and the rapidity of her economic recovery. Always an inventive, skillful, and industrious people, the Germans are once again working, producing, and building with much of their old zest. Although the physical scars of war's destruction are still appallingly evident in the major cities, rebuilding is proceeding at an accelerating pace. But no one can say with assurance that the phenomenal recovery in the material realm is matched by a revolution in the character and attitudes of the German people. Progress in this realm



The Chemistry Building of the Free University of Berlin is again in operation after being partially destroyed during World War II. (Courtesy HICOG Photo Unit.)

cannot be measured quantitatively nor charted on graphs. Yet this is the heart of the German question. It was plain from the first to Western occupation authorities and anti-Nazi German intellectuals that unless a drastic reorientation of the German mind and national aspirations could be effected, her re-emergence as a great economic and military power would only nurture the seeds of new global conflict.

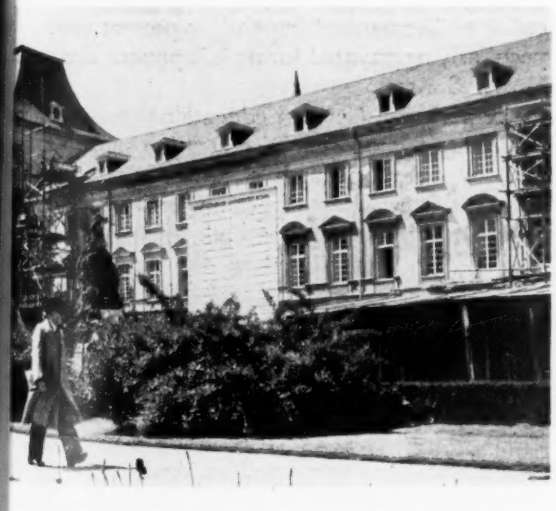
It was a foregone conclusion that the psychological transformation of the Germans was not a task merely of the next few years or decades. To a people that traces its traditions back to the Middle Ages, the eight years of occupation are little more than a fork in the road leading over the hill to an unknown destination. But in the longer process of reorienting the German mind, these years are significant far beyond the brief span of time involved. With recovery comes renewed confidence and the rapid subsidence of the malleable postwar state of mind which welcomed guidance and was prepared to acquiesce in drastic reforms; with the restoration of order comes the revival of old attitudes which, once set, may prove to be decisive for decades to come. Second and third thoughts are becoming vocal and the sense of guilt and memory of past evils is fading with the sheer passage of time. The temptation to settle back into the traditional ways is strong. No reasonable person expects the Germans to be any less German as a result of their rehabilitation. The aim is to help them embrace a mode of individual and national self-government and self-development that will contribute to the larger ends of the peace of the world and the freedom of other nations.

Nowhere in German life is the grip of tradition more apparent than in the universities. Some German educators believe that the optimum period for re-examination and reform has passed already and that the universities, after doing lip-service to new thought under the prodding of English and American occupation authorities, are quietly reviving many of the old discredited forms and practices. This pessimistic appraisal is not without grounds. It is doubtful whether the rank and file of German university professors are deeply persuaded of the need for a reconstruction of the philosophy and aims of higher education. Because the war and its aftermath brought the training of teachers to a standstill for nearly a decade, the teaching faculties of the now largely rebuilt universities of the western zones are staffed predominantly with prewar Ph.D.'s. They have not forgotten that the German universities were once among the most celebrated in the world and that they served as models for the graduate and professional colleges of the New World. Moreover, a degree of aggressive cultural chauvinism and dogmatism has long been associated with the intellectual passion that has been the hallmark of the German scholar ever since Fichte. In the light of these facts, it is not hard to understand why German educators are disposed to be skeptical of advice and guidance from other nationals, especially Americans, whom they find it difficult to accept as cultural equals. Add to this the fact that some faculties still contain remnants of unreconstructed Nazis and one can see why competent observers despair of thorough-going reforms.

Nevertheless, such a gloomy view is premature. There are many lively new departures in evidence and a growing volume of discussion and soul-searching about educational philosophy, aims, and methods. It emanates chiefly from a leaven of far-sighted scholars and critics who are open to new ideas and willing to experiment. Among them are distinguished professors who stuck heroically to their posts and survived the Nazi holocaust without capitulating; others who fled to America and England and returned with fresh perspectives; and young *Dozenten* who, having experienced little of the glory but much of the shame of the old order, are receptive to new thought. The present *Rektors* of the Universities of Bonn and Frankfurt are American citizens, a state of affairs that would have been unimaginable twenty years ago. The Free University of Berlin, in the fortunate position of having no settled traditions to restrict its aims and policies, is in several respects one of the most ac-

vanced and alive educational centers in the world. New institutes are being founded for the purpose of promoting research and study in the social sciences and in American and Anglo-Saxon culture. And German educational journals are filled with discussions of general education, teacher training, political and social education, and the articulation of school and college work. These are some of the grounds for hope that the German educational community may yet throw off the pall of political apathy and traditionalism and confront the new situation which presents such a challenge to education, not only in Germany but all over the world.

The reforms, as yet more widely discussed than practiced, aim in the main to recall the universities to their ancient task of serving as centers of humane learning and the spread of general enlightenment. This ideal, an inheritance from the Middle Ages, became the guiding idea of the German university when, in 1809, the great humanist Wilhelm von Humboldt became Prussian Secretary of Education. It was to be the aim of the universities, he held, not to nationalize man but to humanize the state and to serve the ends of indivudual self-realization. In the context of the romantic idealism that so deeply affected the German outlook all through the nineteenth century, the idea of the university and the ideal of the scholar became impregnated with a kind of quasi-religious mystical spirit. Dedication to the life of learning entailed a life apart, the monasticism of the study and the laboratory. It was service in the order of Truth with a capital T. The professionalizing of the scholar and withdrawal from the mundane interests of politics and society



The main building of Bonn University, damaged during the war, is being reconstructed. (Courtesy of HICOG Photo Unit.)

Foreign students pitch in to help rebuild Frankfurt University. (Courtesy HICOG Photo Unit.)

followed. The scholar was at one and the same time the realization of the highest human ideal and the acme of harmonious personal development; and science (*Wissenschaft*) became not merely a disciplined search for the solution of problems but a complete life whose devotees constituted a special elite or cult. These ideas tinctured, in the emotionally charged writings of Fichte, with authoritarianism and mystical nationalism, set the ideal of German university life. It was a conception embracing a perplexing medley of liberal and dogmatic elements containing the unmistakable imprint of Fichte's subjective authoritarianism.

Propelled by this ideal and under the impact of the rapid specialization of knowledge, the universities were transformed, by the beginning of this century, into pure research institutes with the added duty of providing intensive technical training in the learned professions. German scholars, filled with a romantic passion for abstract learning, earned a reputation for *Gründlichkeit*, endless patience and exhaustive attention to detail, and they became the toast of all other lands, especially the U.S.A. But the passion for research and the pursuit of balanced, humane, cultural learning are not identical. Long before World War II began it was apparent that the German universities had lost touch with the realities of the political life of this convulsive century. In consequence, they were mastered easily by the dictators of the Third Reich.

What happened during the rise and fall of Nazi-

dom revealed the fatal weakness and points a lesson to the West. Either because of too ready compliance with Nazi edicts or through self-immolation in a frenzy of patriotism, almost all research and teaching that did not serve the state and the cause was abandoned. Because the universities were the wards of the state and the professors were state officials, they were in no position to be the moral critics of the complete subversion of government in the Third Reich. The church groups proved to be far more courageous and effective than the intellectuals in resisting the Nazi tyranny. And this also is food for thought.

The visitor to the German universities of the West Zone today gains a strong impression of deep wounds left everywhere by the capitulation of the intellectuals. The physical destruction of many university centers was matched by the shattered integrity, the complete loss of the sense of direction and confidence, and the consequent decline of intellectual vigor. Although the rebuilding of the physical facilities has moved ahead briskly, the reconstruction of staffs, program, and basic educational philosophy has been slow, sporadic, and halting. It has been beset by traditionalism, unresolved resentments built up during the war and the occupation, by the dearth of vigorous young teachers, and by the critical lack of funds for education at all levels. Most of the bomb-ravaged buildings have now been rebuilt, stone by stone, just as they were. One could wish that somewhere, just for its symbolic value, the old structures had been razed and a completely new beginning made in modern architecture. The painstaking restoration of the old buildings is a symbol of the intention to reinstate the old educational program, stone by stone, with all its archaic protocol, academic cultism, professionalizing of learning, and overweening intellectualism, when the need is for balanced human development and living experience with concrete democratic social and political forms.

In constrast with this as yet indeterminate state of affairs is the situation in the East Zone. From the disjointed information leaking through to the West, supplemented by official Soviet propaganda handouts, it is evident that the Russians are making the schools and universities over so as to serve their ideological and political ends as efficiently as possible. They enjoy for the time being the advantage of their basic totalitarian vice in that they have a definite plan and the authority and ruthlessness to carry it out. A broad grants-in-aid program is in effect favoring "workers, peasants, or their children" and is bringing to the universities the talented in numbers sufficient to provide the engineers, doctors, teachers, and so forth, needed to carry out the "Plan for the People's Economy," and, of course, to insure a future governing intelligentsia indoctrinated with Marxist-Stalinist social and political principles. Similarly, the curriculum and program in the universities under Soviet control are not permitted to develop freely. The published Regulation of May 21, 1951, inaugurated a system of vice-chancellors, four in each university, who are in reality cultural commissars in charge, respectively, of social science, research work, scientific career aspirants, and student affairs. Always keen to capture the minds of men, the Russians are said to be spending a greater percent of East Germany's annual budget on "education" than is the case in West Germany.

In sum, the East Zone presents the familiar pattern of despotic control, adjusted to making education serve the ends of totaliarianism, but seeking as always to restrict the development of the mind to the "safe" boundaries defined by the state and the official ideology.

In the West Zone, postwar reforms have established a true federal structure with self-government and local option at lower levels. In this system the control of education is in the hands of the *Länder*, rather than the federal government, and there is in consequence a wholesome diversity in the character and programs of the universities of the different provinces. But everywhere the visitor finds university people pondering ways and means of correcting the imbalance between the technical training needed for the professions and research and the broad cultural education which should lead to a deeper insight into and concern for the existing human situation. This problem is not peculiar to Germany although it is present there in a peculiarly aggravated form; it is present also in the United States.

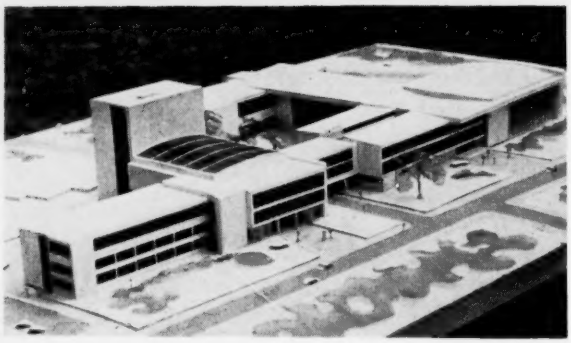
Formerly the German educational system aimed to impart a good general education in two steps: first, by devoting much of the last seven of the normal thirteen years of pre-university schooling to general education; and second, by setting the professional training offered by the universities in a generous perspective of related fields and problems. But the training in the preparatory schools has proved to be much more effective in imparting an appreciation of Germany's national cultural heritage than in teaching students to think for themselves, especially in the areas of civic responsibility and national and world politics. And the training in the learned professions has been plagued in Germany as everywhere else by advancing specialization and the consequent need for more and more

The newly constructed reading room at Frankfurt University. (Courtesy U.S. Department of State.)

technical training, coupled with the economic necessity, on the part of the student, to complete the course of training as rapidly as possible. Thus the student is encouraged to concentrate ever more and more in technical-vocational courses to the neglect of the liberal education that would help him to understand the significance of his vocation as a man and citizen. It is a familiar problem, but it is of crucial importance now in Germany.

Recognizing Germany's peculiar need for leaders of cosmopolitan outlook and gifted with political insight and philosophic wisdom, German educators are trying in various ways to supplement the training in law, medicine, engineering, research, teaching, and related professions with studies aiming to continue the student's cultural or general education. There is much discussion among them of *studium generale* or *universale,* and a number of experiments are in progress. Conservative educators view these departures with skepticism and characterize them as "unsound," a common academic objection to new thought and fresh attacks on old problems. Nevertheless, at every major university and even in the *Technische Hochschulen* a nucleus of professors, sparked in some cases by visits to the U.S.A. and England and with the encouragement of the occupation authorities, are introducing studies designed to continue the general education of university students and adults.

In some institutions *studium generale* means little more than encouragement given to lecturers on technical subjects to dwell on the general implications and wider bearings of their specialties and the interconnectedness of concepts in related fields of inquiry. And this is surely one of the best ways, provided a university is blessed with teachers who are at one and the same time capable specialists and persons of broad and deep culture. But since such men are rare, various other measures are under consideration and trial. At the Free University of Berlin, at Munich, Bonn, and Freiburg, for example, there are series of special lectures on topics of general cultural interest. These are open to all students irrespective of the special "Faculty" under which they are enrolled. Bonn and Freiburg, among others, also make available discussion and workshop groups in connection with *studium generale,* so that the student may explore the philosophical ideas and values which underlie individual and community life. A more ambitious plan is in effect at the Leibniz College of Tübingen University, a residential college where students who have completed their preparatory work may take a special program of general studies, serving as a kind of



A model of the library and the auditoriums of the Free University of Berlin. (Courtesy U.S. Department of State.)

bridge to university work. It began as a special service to war veterans who had been long out of school, but it proved to be so attractive that it continues to attract students. It is the nearest thing yet in Germany to the first two years of the American college with its emphasis on integrated cultural or general education.

The problems encountered by these projects may well be imagined. Programs of general lectures without any sort of continuity or follow-up are of limited value, and are not highly regarded by the rank and file of students who are bent on completing their professional training in the most expeditious way. A voluntary attendance of about ten percent of the student body at general education lectures is considered good. On the other hand, a comprehensive and integrated program such as that at Tübingen means a substantial added outlay in time and the cost of education. This raises a host of stubborn problems, especially in present-day Germany where the economic stringency of *Länder* exchequers is making it difficult to provide an education of even minimum standards.

The American observer may be tempted to feel that the Germans should import the idea of the Anglo-Saxon college and sandwich it between the pre-university *Höhere Schule* and the professional university education. But this could not be done without a general recasting of the whole system of German education from top to bottom. The German student normally reaches the university after about thirteen years of schooling and at the age of nineteen. In other words, he enters "higher" education approximately one year later than the American college student. In the past it was assumed that the longer course of secondary schooling pretty well answered the need for a broad cultural education. But this assumption has been called into question since the war by critics who feel that the preparatory years have been saddled with premature specialization in a heavily prescribed curriculum, and moreover, that the teaching in the schools is deficient in freedom and vigor and is more conducive to rote leaning than to the development of depth of understanding and ability to think for oneself. There is a growing awareness, therefore, that the university must somehow provide not only technical professional training but also a continuing opportunity for liberal humane education.

There is a growing awareness, too, of the need to make university study, as well as the preparatory classical *Gynasium,* available to the sons of farmers and workers. In the past there have been no legal restrictions to their matriculation, but in the mores of German society it was just not the thing to do; and this state of affairs is still accepted as normal, even by the lower classes who take this educational disenfranchisement with characteristic docility. Since the state's civil servants and top business executives are recruited from the ranks of university graduates, this system helps to perpetuate and intrench the authoritarian class structure which prevails in German political and economic life. The deepest and most far-reaching need of Germany's rehabilitation is for greatly accelerated social mobility. To extend equal educational opportunities to able young people of all classes would be a big step toward this end.

An aspect of German university tradition that raises the most serious doubts in the American observer is the formalism and distance in faculty-student relations and the lack of a coherent communal life. In the past the university student moved in a kind of strange social and political vacuum, relieved only by the *Burschenschaft* or the casual sociability of the lodging house. The German university was a place for single-minded concentration on the formal and abstract training of the intellect. By contrast, the English and American colleges carry on their work in an atmosphere of cordial helpful relations between older and younger scholars. But in Germany, the professor has traditionally barricaded himself behind the dignity and special status that goes with being a *Herr Professor Doktor.* Instruction is still given with but few exceptions by means of the *Vorlesung* or lecture, and it is not uncommon for the professor to dictate a good part of the class hour to students who dutifully copy all into their notebooks. Because of rising enrollments and a deteriorating teacher-student ratio, the lecture hall of a popular professor may contain from fifty to five hundred students. The tradition of professorial aloofness and infallibility coupled with the paucity of small seminars and discussion groups creates an atmosphere in which it is the height of

presumption for the student to ask a question, draw out the professor, or have a brief tilt with him. It is a system of professors, by professors, and for professors, designed to provoke blind discipleship instead of independent thought among students. It is also the perfect seedbed for the future citizens of the paternalistic authoritarian state which knows best what is good for its citizens, whose duty it is to listen but not to talk back. Individual professors here and there as well as various adult educational agencies are sponsoring discussion groups, colloquiums, and seminars, often at great personal sacrifice of time and energy. Many of these are centered in the *Amerikahaus* or the Information Library centers that are serving both the German and the American people better than they know.

Because most universities in Germany provide few student residences or none at all, there is little opportunity for the give and take of the dormitory "bull session" in which students educate each other. The beer halls and fraternity meetings are still the scenes of such discussions, but under conditions that are far less wholesome and maturing than college dormitory life. Moreover, the traditions of the German fraternities (*Korps* and *Burschenshaften*) are so deeply tinctured with chauvinism and cabalistic nonsense and so devoted to beer-guzzling and duelling that thoughtful German educators view their current revival with deep misgivings.

American occupation authorities have encouraged the universities to establish new patterns for student and student-faculty community life. Student residences have sprung up at Göttingen, Freiburg, Munich, Heidelberg, and Tübingen, to mention only a few. In some cases these serve as centers for special programs of general studies. McCloy funds helped generously in building student social and study centers at a number of universities. But it appears that we have been more lavish with our money than with the thoughtful counsels of experience and the expert advice that would help the Germans make good use of these new facilities.

Another new departure is the encouragement given to student self-government as an exercise in community management, democratic practices, and political self-expression. The Free University of Berlin has developed student responsibilities to a very high level, even to the point of seating two student representatives on the University Senate. The student government also sponsors a group of active political clubs, each in support of a national political party; they rise above partisan politics, however, in a joint effort to assist German students and professors in the East Zone with books, moral support, and even monetary assistance. This is also a major project of the German National Union of Students (ASTA). But there is as yet little evidence that German faculties or students are aware of the values of student newspapers and other voluntary, self-managed, extracurricular activities which are such a valuable training ground in political self-development on English and American campuses.

The volume and depth of the new stirrings, significant though they are, are not such as to provide grounds as yet for confident optimism. The task of creating a new university, in fact as well as in idea, a university competent not only to advance the frontiers of knowledge but dedicated above all to humane ideals and to nurturing the growth of those values which enable men to live with each other democratically and peacefully in freedom, such a task puts the German people and their mores and traditions to the supreme test. The occupation authorities can suggest, advise, aid, and even threaten, but in the last analysis it is the responsibility of the German people to confront the problems and to proceed to their solution with sincerity and determination. These conditions do not yet obtain, at least not in a sufficient degree to give assurance of a constructive outcome.

The fact is, the terrible self-inflicted ordeal through which Germany has passed consumed her soul far more completely than it destroyed and divided her land. It is relatively simple, in view of her amazing economic recovery, to rebuild the damaged university buildings and fill the classrooms and laboratories once again with eager learners in search of financial and personal security. But to restore the broken morale, to overcome apathy, bitterness, fear, and resentment, to root out the residual pockets of old accumulated poisons—all this will take time and patience, and wise, alert, and magnanimous surveillance.

Even in this period of transition, the German universities are once again providing a high level of training in the major professions and again setting the high standards of research for which they have long been justly famous. There is every reason to believe that they will continue to be a bulwark against the spread of Communism in Europe; for the liberal and progressive intellectuals share with the surviving Nazi bitter-enders an antipathy to Communism, although for quite different reasons. But resistance to Communism, essential as that is, is not enough. There are as yet few signs that the universities and the world of scholars are alive to the positive part that they must play in the moral and spiritual regeneration of the German people in a democratically united Europe.

Laziness and the Scholarly Life*

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SIXTY years ago William James said, "Psychology is a science, and teaching is an art; and sciences never generate arts directly out of themselves. An intermediary inventive mind must make the application, by using its originality." Nothing has happened in the years since James wrote these words to lessen their wisdom. What James said about teaching may with equal assurance be said of research and a life devoted to pure and applied scholarship. Therefore, let us think for a little while about these arts and of psychology as applied to the career of the scholar.

A few years will pass and some who have received graduate degrees will be famous because of the contributions they will have made to pure or applied science and to scholarship in general. A few others, it is more than possible, will not justify the promise that they had shown as graduate students. Why is this true? In order to answer this question let use examine some of the factors that may make for success or failure in the competive but also rewarding world of free American scholarship today.

At the outset, certain assumptions may be made. Most of those who receive doctor's and master's degrees possess inborn intellectual ability of a high level. They also have profited by exceptional educational opportunities. Thus both heredity and environment have been good to them. The examinations and other selective procedures of excellent universities have eliminated many who started out to do graduate work but who did not possess the qualities of intelligence or diligence necessary to win high and recognized degrees.

We need not, therefore, think too much about inborn differences in basic ability or differences in past academic work in considering the probable future achievements of academic scholars in what the Germans call the *Gelehrten Welt*. Rather we must look at other qualities of personality and character that also determine to some extent success or failure in the long pull of an intellectual life.

Let us clear the decks a little. First of all it is certain that most individuals who are acclaimed as successful are not lazy. The only exceptions to this rule are a few fortunate individuals who by one notable discovery or invention rise like a rocket to full luminosity and then somehow, in defiance of the academic law of gravity, continue to convince society that they are maintaining through long later years the promise of that one early burst of illumination.

Laziness is a characteristic of the personality that most of us more easily recognize in our friends than in ourselves. Moreover, laziness is not a word that appears in the table of contents of most technical books on psychology. The reason is clear. If one starts to analyze any man's psychological makeup, that is, to dig in his mental garden to find the buried capsule called laziness, it will probably not be disinterred. But as the investigator turns his spade he may, as has sometimes happened to seekers for buried treasure, uncover some other valuable finds. Such digging will almost certainly unearth processes of importance, some of which have real psychological significance and are related to what the world calls laziness. One of these processes may be called *motivation*, another *sustained attention*, a third *self-control*.

Additional characteristics, which have been given such names as interest, perseverance, determination, and even single-mindedness, may also be found by one who digs in the hope of finding

* Taken from an address delivered at the Graduate Convocation of Brown University, May 30, 1953.

the true mental basis of laziness. It may, therefore, be worth while to look at some of these processes if we are to make an even partly informed guess as to why individuals of similar intellectual ability are not always equally successful in achieving a life of truly productive scholarship and of professional, academic, or research distinction. As we examine this situation one point becomes clear at once. In every walk of scholarly or practical life, those who get things done are preferred by society to those who do not. The prizes of life go to those who decipher the inscriptions, solve the equations, or improve milk production, rather than to those who convince themselves that these tasks cannot be done in the face of inevitable handicaps.

This means that real academic awards are generally given to hard, ingenious workers who learn to transcend the petty annoyances of life. Yet even this statement is dangerously like a paradox. We moderns live in a world which likes to pretend that diligent work is a kind of evil. The image of Eden is too often and too clearly before us. We take too literally the idea that it is man's punishment for the wickedness that he did in his first garden which requires him always by the sweat of his face to earn his bread. "More pay for less work" is consequently one of the popular slogans of our age, but it is certainly a fatal policy for one who would be a scholar. In recent years it has not always sounded funny to say of a man that he believes that the world owes him a living. Some of the fanciful lists of human rights and privileges that were so prettily printed in two great English-speaking capitals in the nineteen thirties and that guaranteed many things from the cradle to the grave really boil down to an invitation to the individual citizen not to work, at least not too hard. If a whole society ever is hypnotized by the odd idea that some sort of superstate can provide the necessities and even the luxuries of life without requiring individual responsibility and work, it will be difficult for the scholar to realize that this attitude must never apply to him.

Laziness, or the avoiding of hard individually motivated work, is thus not today an abstract problem. Where laziness is involved socially determined desires and wishes or individually held levels of aspiration may be called in question. What does an individual truly want to do? In literary and most nonphysiological language, what is deep down in his heart? These are the basic questions. A man can be said not to be lazy when he has what may be called the motivational machinery that makes him keep on working at activities that he and an informed segment of society believe he should do because of his aptitudes and previous opportunities.

The following sentences appeared in an article written at the time of Stalin's death: "His mother baked, sewed, and washed for more prosperous neighbors, supplementing with these earnings her husband's income. Her position in the family, however, was typical of the slave status of the European peasant woman." There is a hidden value judgment in the use of the word "slave" here just as there is in the unjust use of the word in characterizing certain pieces of modern labor legislation. I read this excerpt about Stalin's mother in an airplane while going from Washington to Boston. There were about forty passengers in the plane. One small delicate girl, a college graduate, and not at all improbably a corporation official's daughter, neatly, effectively, and smilingly prepared trays for all passengers, served them supper, separately gave them coffee, collected trays, read notices, and did a little required paper work. Is this typical of the slave status of the airline hostess? Is it not possible that neither Stalin's mother nor the airline hostess felt especially sorry for herself as she worked? Both were doing well and effectively something that was worth doing and that lay clearly within their powers. In both cases the result was an effective performance and the inner satisfaction that arises from useful work well done.

Most young scholars at the outset of their careers think that they will avoid laziness. This means that they plan more or less consciously to develop effective self-management of their own motives in work and play. Above all, it means that they try to establish for themselves a discipline for the efficient use of time and a rigorous determination to do well the tasks related to their fields of scholarship. Such persons must quickly learn to avoid doing the many other things that society will press upon them as alternatives for constructive work. The president of the Royal Netherlands Academy of Science recently reported a colleague's observations on a fellow research man: "He is getting old; he now attends concerts."

It is a guilty secret of modern psychology that more is understood about the motivation of thirsty rats and hungry pecking pigeons as they press levers or hit targets than is known about the way in which poets make themselves write poems or scientists force themselves into the laboratory when the good golfing days of spring arrive. In spite of this lack of knowledge there can be no doubt that thirsty rats, hungry pigeons, and composing poets act as they do because they have by the positive reinforcement of former rewards for action come

to do what they do and not something else. At this level of endeavor, in spite of Adam's curse, the distinction between work and play often disappears for both animals and men.

The name work is ordinarily applied in psychology to any consistent performance carried out by an individual and directed toward a constructive end which is approved by society. The Supreme Court of the United States, in the Jewel Ridge case, has defined work in a legal but not psychological sense as involving all three of the following conditions: (1) physical or mental exertion whether burdensome or not; (2) exertion controlled or required by the employer; (3) exertion pursued necessarily and primarily for the benefit of the employer and his business.

Thus it is clear that legal "work" may be psychological "play."

I belong to a society in England that is made up of research men who are interested in the science of human work. It is called the Ergonomics Society, that is, the society of the laws of work. The laws it is interested in are not statutes but are natural processes. One can be assured therefore that this society of psychologists, physiologists, and human engineers is not yet worried about what to do when all its problems are solved. It does, however, find that it must now primarily deal with human capabilities and aptitudes, efficiency of movement in time and space, and a whole related set of problems of motivation and learning that are related to behavior.

One of the great problems of all who study this field is to avoid the use of ambiguous words. An example may make this clear. A year-round resident of coastal Blue Hill in the State of Maine, whose vocation is fishing, considers the setting of a gill net for mackerel to be hard work. A Wall Street banker vacationing in the same region performs the same action and considers it play of the best kind.

It is clear that to the greatest degree possible scholarly work should be done in a way that makes it as much like play as possible. Those who have attempted to explain play suggest that among the physiological and psychological factors that initiate it are the following: enjoyment in the body's own activity because of the stimulation that movement provides for the sense organs in muscle tendons and joints, and in a related way the exercise of any intellectual skill; delight in achieving success in bettering one's own record of performance, or in excelling over a rival or rivals; the social satisfactions that come from informal friendly competition and companionship; and the opportunity to avoid concentration upon the difficult problems of everyday life. In these senses play is sometimes a wholesome retreat from the hard pressures of reality, but when its performance also advances the solution of real problems, as in some true scholarship, it is doubly sweet.

Work, on the contrary, is still often thought of as required by an employer or as an "Adam's curse." This is true not only on the automobile assembly line but also in the stacks of the university library. In every American college faculty club some scholar has been heard to say, after a two-hour lunch, "Well, back to the galleys."

The motives then that determine worth-while scholarly achievement include all those that have been mentioned in connection with both work and play, as well as the following: the desire for, and need of, economic reward for the successful completion of required tasks; a desire to gain "closure" or logical completeness in some previously unstable, unsolved, or unsettled intellectual question; a desire for esthetic satisfaction; and a series of socially determined motives such as pleasing a particular teacher, a former research colleague, a particular group of critics, an editor, a supervisor, an audience, a group of students, or, be it whispered, even a college dean or president. Anger or the desire to prove someone wrong is sometimes also a motive in intellectual endeavor. It is not usually a satisfactory one, however. Saint James may have been thinking of scholars when he wrote, "Let every man be swift to hear, slow to speak, slow to wrath."

The academic man must somehow learn to manage his motives himself if he is to become a competent scholar in this confusing age. Those who are proficient in psychoanalysis, or what is called "depth psychology," are convinced that many of man's compelling motives are unconscious. Such personality clinicians think of hidden wishes as having a deep meaning in determining overt action. This is surely not the place to evaluate the scientific basis of this view, for few academic people can afford to pay in time or money for a complete psychoanalysis before getting down to scholarly problem-solving. Confusing nonconscious motives are undoubtedly important in all our lives, but sometimes such motives can best be dealt with by forgetting about them and just working hard. To allow a theory of the unconscious to serve as an excuse or a rationalization for a failure to try hard day-in-and-day-out intellectual labor is not wise even in this mid half-century of psychoanalytic theorizing.

As already suggested, laziness, or faulty motiva-

tion, conscious or unconscious, is forever working against scholarly achievement. In earlier and simpler days monastic scholars summarized these antiwork urges as temptations of the devil. Today in our complex civilization the devil has learned new ways. The golf links, and its apparently necessary exercise, the deceptively worth-while television show, the half-popular magazine, the worth-while newspaper, are but a few of the tools that our modern Beelzebub employs to keep today's scholars from giving long hours to hard mental endeavor.

When the telephone bell rings the scholar stops and talks. Letters come to the scholar's desk; he answers them. If the scholar is a university professor, or even an industrial laboratory man, committee meetings call him. For many academic minds there is no categorical imperative so compelling as a committee to consider providing a new rug for the faculty club, or a new way of adding required courses to produce that subtlest of objectives called "general education."

Home life and the legitimate requirements of family existence, more than in simpler days, now present hazards for the intellectual man or woman. European scholars shake their heads over American colleagues who do the marketing and cooking and who wash the dishes after dinner. Each year it may be that housework becomes a more formidable competitor for the research time of the academic man. This is an example of the new scheming of "Old Nick." Young scholars may well remember that those who are forewarned can sometimes be forearmed.

Physiology raises its scientific head when we think of efficiency and work. Sleep, still a mysterious process, is a problem for the scholar. There may be differences between individuals in the amount of sleep required for efficient normal work. Habit plays a part in determining the number of hours wisely given to sleep. Some individuals waste far too much time sleeping. To convince himself that eight hours of sleep each day is necessary may be the merest rationalization of a self-pampering scholar. There is good evidence, however, that certain individuals work at less than full efficiency when they do not have a basic minimum of sleep each day. A lowering of efficiency is often notable in the sleep-starved Bohemian scholar who loves to talk or sing with congenial spirits far into each night. It is true that errors and other signs of sleep loss or fatigue are not necessarily seen in short samples of mental work when the individuals who are doing the tasks are properly motivated. In the long run, however, reasonably rested individuals work best. But sleepiness may be an excuse to get out of work. Many a scholar has learned that when he is too tired and sleepy to do even the routine spade work required in his research, he is not too fatigued to play an intellectually taxing game of bridge. Alcohol and even tobacco when unwisely used, and especially when added to sleep loss, may trap the unwary scholar and hold him back from real achievement.

By trial and error each scholar who is to be successful must work out for himself in a way that is satisfactory for his own psycho-physiological makeup the answers that he will give to himself as to why he should do or not do the many things that are bound to arise in life as distractors from his basic scholarly tasks.

Granted reasonable health, a satisfactory home life, appropriate food and exercise, some sensible recreation, why is it therefore that some scholars achieve intellectual miracles while others never justify the promise that they demonstrated as graduate students? No general answer can yet be given to these questions. Some reason for human failure can be described in theological terms. Moral lapses are basic to many such failures. The old sin of avarice, that is, the inappropriate and inordinate desire for money, leads to many a good scholar's downfall. A position offering less opportunity for research and for stimulating intellectual work but at a higher income is snapped at by some young scholars. Many promising careers have been wrecked on this gilded rock. Shining skulls which once held good brains show their brows in not a few university administrative offices. A preoccupation with the stock market or with paramutual odds is seldom a help in scholarly work. Humor and a sense of proportion are ordinarily assets in any life, but sometimes at the outset of a scholarly career too much humor or too much ability to see problems in full perspective may be a liability. It is dangerous to laugh too much at the minute labor required in one's own research.

Some individuals fail in independent work even though they do well in the directed activities of college and graduate school. This fact may be closely related to some of the deeper and less easily recognized motives of the personality. A good academic apple polisher, for example, is not always a good independent grower of apple trees. In such individuals the necessary drudgery of scholarship has been energized by some secondary end rather than because of its intrinsic intellectual interest. Some persons all through life are looking for pats on the head from a parent or parent substitute. Some of these praise seekers can reconvert themselves after leaving graduate school by thinking of the criticism or possible praise that a wider pub-

lic or some notable scholar may give to their publications. Such individuals often make up the little coteries or schools which cluster about strong academic figures only again to feel orphaned when the hero-scholar dies or succumbs to arteriosclerosis of the brain.

This reliance on an older and wiser person in scholarship may not be all bad. Not a few scholars, by using the old technic of the runner in training and by selecting a pacemaker, have succeeded in speeding themselves up. To emulate another individual in research productivity and even in style of work may help some beginners. It is true, however, that the scholar who feels that his research or related academic or professional work is done purely for financial gain, for social recognition, or for approving letters from pontifical academic figures should reexamine his own motivational machinery. He may find that it is not too late to reorganize his basic attitudes toward life in such a way that the real pleasures and ends of scholarship and the fun of understanding, for knowing's own sake, will become for him more important than praise. This transition is symbolized by the boy who as an undergraduate works for election to Phi Beta Kappa but who later finds that scholarship itself is interesting, exciting, and rewarding.

Conflicts in motivation are bound at times to disturb the lives of all scholars. There is hardly a mature worker in the academic vineyard who does not realize retrospectively that he has had both good and bad vintage years. Many a scholar has had his career given a jolt by falling in love or by too much attention to baseball or horse racing. Such romances are most disturbing when they are not socially approved. Here again in old-fashioned terms sin is seen as the foe of the scholar. Since matrimony has been mentioned, it may be observed that the academic man who marries a wealthy wife, or indeed one not so wealthy, with social objectives or a passionate love of travel or even of gardening, must be alert from the first to preserve his time schedule.

Nevertheless, the young scholar should try not to blame his environment for delays or failures in research. Such excuses often involve verbalizations that are more dangerous than is the mere failure to work. Every large college faculty or research organization has a number of individuals with full academic training, good intelligence, and self-acknowledged zeal who nevertheless do not produce important research results or publications. Such individuals, if they are observed carefully, that is, given a sort of informed academic "time and motion study," will not infrequently be found to fill their days with unimportant but time-consuming activities. These men and women sometimes occupy themselves with interminable files of research cards, with better and better glass blowing, or the making of private glossaries. They then assert that more uninterrupted time is necessary for them if they are to produce a satisfactory intellectual product. The petty daily and hourly demands of existence related to eating and the toilet are sometimes built up by such individuals so that gradually the weeks and the years close in upon them without the dreamed-of great book or the imaginary crucial experiment being made a reality. Thus the epic does not get written, and the Nobel prize remains unwon. The reasons given for failure are almost never the real ones of poorly managed motives and a bad personal use of time but rather some trumped-up claim that the outside world, or worse still, in incipient paranoia, that some other individual is responsible for the sadness of failure.

On the other hand, great works of scholarship and creative skill have been carried to triumphant conclusion under most disadvantageous environmental conditions. Trollop's novels are not the less outstanding because he arose early and wrote a certain number of words each day before taking up his work of managing the British postal service. James Mill's great work *The History of India* was written around the family table. His son, John Stuart Mill, as a child of seven and eight, was allowed to interrupt him to ask the meaning of any Greek word that he did not know in his lessons because he had learned Greek before Latin and the family lexicon defined Greek works only in Latin. Under these conditions the elder Mill produced one of the great works of historical scholarship of his generation.

Many students find it helpful to set mild punishments for themselves if their allotted daily tasks are not performed. Most scholarly workers indeed find that they must solve the problem of not allowing apparently unfavorable environmental conditions to interfere with work that they must do. It is helpful to remember that psychological experiments on distractions show that interpolated noise or other unpleasant interruption instead of cutting down work actually may at times have a so-called dynamogenic effect and make the individual do more and better work when the distraction is present than when it is absent. Thus, the scholar who complains of the radio in the next room, the glare of the library light, or the whispering of his companions is beginning to show danger-

ous signs of blaming his surroundings for his own shortcomings. Here again, in theological terms, one should repent ere it be too late! Few scholars in our modern active America are able so to control all the conditions under which they work, and ideal conditions are rare. Many scholars who now ask for soundproof work rooms would go to sleep in them if they had them. If all works of scholarship had to be accomplished under ideal external conditions, the output of the intellectual world would be reduced to a trickle.

And so, may I hint at what old commencement speakers used to call their formal charge? Our world today as possibly never before needs hard-working, well-trained, objective, scholarly men and women. In uniform or in civilian clothes scholars may be efficient or inefficient as they themselves choose. One must learn so to manipulate his own attitudes and emotions that he will feel at the end of his career that he has approximated in achievement the potentialities which he knew he possessed. When one is first called "Master" or "Doctor," it is a good time to make some concrete resolutions about the self-management of motives and the use of time. The self-imposed discipline that may grow from such resolutions may well make for years that are happy with intellectual achievement. Walk around, climb over, slide under, or crush the obstacles that lie ahead and enjoy a steady life of scholarly achievement, but do it in a way that will give you a full share of the gayety and fun that should come to each well-planned life.

Uniform Substitutions of Corresponding Instances in an Established Form

> He not only learns to salivate at the appropriate moments, or to recite the appropriate nonsense syllables; he also, in some way, *learns to learn.*
>
> —Gregory Bateson, "Social planning and deutero-learning", in *Readings in Social Psychology* (Holt, 1947), page 123.

At last some sociologists, psychologists, and many anthropologists have
become convinced that certain experiments demonstrate that at
times animals can learn to learn;
In parallel expression, we can say that those who covet actually
yearn to yearn.
This handy-dandy kind of phrase fits others like a glove:
The erstwhile Wolf we now define as one who loves to love.

If a Senator or Congressman interrupts another and asks permission for
the floor, we now would say that the gentleman talks to talk;
And in contrast to a stubborn mule, the racehorse balks to balk.
Similarly, the Big Man On The Campus has to rate to rate,
While the gentle pacifist really hates to hate.

Sometimes in a track meet, particularly when there are many more
runners than can be accommodated at any one time, they have
preliminary heats and we assert that the runners race to race—
But we must ignore the fighters who are standing face to face.
Does the coward or the hero fear to fear? Does the gourmet or the
gourmand eat to eat? We do not know, and less we care: we leave
them to their fate
Content to know he also serves who only waits to wait.

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Scientific Research and National Security*

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I. The Role of Government in Basic Research

THE National Science Foundation published, during the year 1953, a study of the distribution of funds for federal support of research under the title *Federal Funds for Science.* This study indicates that in 1953 an estimated 3.5 billion dollars or more was spent in this country on scientific research and development. The federal government paid for a little over 60 percent, industry about 35 percent, and nonprofit institutions about 3 percent. Federal expenditures in support of research and development for the fiscal year ending June, 1953, totaled about 2.2 billion dollars—an increase of 0.4 billion dollars over the 1.8 billion dollars expended in the fiscal year 1952. These estimates cover the costs of all research and development activities paid for by the federal government. They include not only work done by the government but also work sponsored by it outside its own laboratories. It should not be concluded from these figures, however, that the government program for research and development is increasing. As a matter of fact, the federal budget for research and development is now decreasing, and the decrease will be reflected later in annual expenditures.

More than 20 federal agencies, approximately half of the total number, administer programs in research and development. Seven agencies, however, administer 99 percent of the total funds. The Department of Defense, with about three-fourths of the total, administers the largest portion; followed by the Atomic Energy Commission; the National Advisory Committee for Aeronautics; the Department of Health, Education, and Welfare; the Department of Agriculture; the Department of the Interior; and the Department of Commerce. Approximately 94 cents of the federal government's research and development dollar goes for work of an applied research and development nature; the remaining 6 cents is for basic research.

How is basic research defined? To the academic mind, the expression presumably has a common meaning: typical academic research in the basic sciences. To representatives of industry and of government, however, the term *basic research* may have other connotations or shades of meaning. The explanation of basic research given by Dr. Bush in *Science the Endless Frontier* covers so many aspects of the entire question that it is useful to refer to it repeatedly:

> Basic research is performed without thought of practical ends. It results in general knowledge and understanding of nature and its laws. The general knowledge provides the means of answering a large number of important practical problems, though it may not give a complete specific answer to any one of them. The function of applied research is to provide such complete answers. The scientist doing basic research may not be at all interested in the practical applications of his work, yet the further progress of industrial development would eventually stagnate if basic research were long neglected.

One of the peculiarities of basic science is the variety

* Based on papers presented at the joint symposium of the National Academy of Economics and Political Science; Sections K and M, AAAS; and the National Social Science Honor Society, Pi Gamma Mu at the 120th Annual Meeting of the AAAS, Boston, Massachusetts, December 26–31, 1953.

of paths which lead to productive advance. Many of the most important discoveries have come as a result of experiments undertaken with very different purposes in mind. Statistically it is certain that important and highly useful discoveries will result from some fraction of the undertakings in basic science; but the results of any one particular investigation cannot be predicted with accuracy.

Inherent in this definition are some of the reasons why government is justified in the support of basic research, especially where it can be demonstrated that such research is not receiving adequate support from other sources. The technological progress that has occurred since World War II and the problems and progress that arise in medical science have demonstrated that a greater effort in basic research is needed in order to support the advances that are being made in applied and developmental fields. It must be borne in mind, also, that basic research is an important part of the training of research scientists and teachers of science, of which there are such critical shortages at the present time. As is known, these needs have developed during a period in which the facilities and resources of the universities have been taxed beyond their capacity. It seems appropriate, therefore, for the government to insure a continuation of basic research by means of the grant-in-aid or contract, by fellowships, and by other types of support.

A Foundation study of federal funds for scientific research and development at nonprofit institutions in the year 1951–52 disclosed that only about 1 of every 5 dollars was for basic research. The other 4 dollars went for applied research, development, and necessary additions to the research-and-development plants. The ratio of 4 to 1 between applied science and basic research seems to indicate a serious imbalance of effort and suggests the desirability of adjusting, to the extent possible, the disparity between the funds going for applied research and those available for basic research.

World War II produced great changes, both in the nature of the research being supported by the government and also in the mechanisms by which it was supported. In the decade prior to World War II, the federal government was sponsoring research at educational institutions at the approximate rate of 6 million dollars annually, most of which was for support in agriculture. The war shifted the emphasis to military research. A great innovation in the federal support of research was the research-and-development contract between the government and universities and other research institutions, introduced by the Office of Scientific Research and Development. The success of the contract system for the support of needed research and development established a pattern that was continued after the war and extended to include the research grant.

The Office of Naval Research and the National Institutes of Health were postwar pioneers in support by contract and grant, respectively, of research, both basic and applied. This support was largely by this "project" method, and they were later joined by the Atomic Energy Commission in its off-site program and by the other military departments. However, the greater part of such research was related fairly specifically to the mission of the agency. Except for the Office of Naval Research, which developed a broad program of extramural basic research, there was initially little support of research, except research more or less closely related to practical ends. The need for federal support and encouragement of unrestricted research had been anticipated even before the war ended, and resulted in a 5-year effort on the part of scientists, legislators, and others, which was finally climaxed in the creation by Congress of the National Science Foundation. The Foundation was established, therefore, not to supersede or eliminate the research programs of existing agencies, but to provide a mechanism for the furtherance of education in science and the support of research on a very broad base. Another important function, in view of the growing magnitude of the government's research programs, was to be the development of government policy with respect to the promotion of basic research and education in the sciences.

In many ways, the interest of the government in science can be compared with that of private industry, since the government must take a practical view of spending public money. Its stockholders are the taxpayers, and what the government does is accountable to them. The technical industries, faced with the necessity of their undertakings paying off, have realized their essential dependence upon basic research and are helping to support it in various ways. The federal government has realized, in principle at least, the necessity of supporting basic research for reasons similar to those of industry but broader and deeper, in that not only the economic welfare of the country but also the health of our people and the strength of our defenses are dependent upon a never-ending search for new knowledge. Traditionally, the general position of the government has been to support the types of activity that are essential to the general welfare and that the states or private enterprise are not in a position to undertake. In other democracies, the list is longer than in this country,

but in the United States the interest is in keeping it as short as possible. In recent years, however, the national welfare has come to depend, to such an increasing extent, on progress in science and technology that the support of research seems to be a proper function of government for a number of reasons.

The first reason for support is the obvious one that the government has need for research results and, therefore, must be able to call upon the most competent brains in the country, wherever these may be found. A second reason is that the interests of the government may coincide with those of non-government institutions. This might be true with respect to either basic or applied research, but more rarely in applied, insofar as universities are concerned (except in the fields of engineering, agriculture, and medicine). The mutual interest of the government and the university opens up the possibility of a cooperative venture with partial support from the government. In such a situation, either the government or the university might take the initiative in proposing the undertaking.

Another reason why the government may properly support basic research arises out of a recognition by scientists that certain areas of research should, in the interest of the public welfare, be enlarged and supported to an extent beyond that which is possible with private resources. After World War II, for example, American physicists realized that the United States was lagging in the field of low-temperature physics, an area essential to the future of physics research in this country. Government assistance, initially by the Office of Naval Research and the Atomic Energy Commission, was forthcoming, especially in provision of facilities such as helium liquefiers, and the research effort in the low-temperature field has been strengthened accordingly. In a similar manner, the Foundation has found that, in the opinion of biologists, systematic biology (taxonomy) was being neglected and that progress in biology was being retarded as a result. Foundation interest in the problem has resulted in the initiation of a broad program in this area.

The interest of the federal government in research is essentially a practical one. If basic research is the seeking for knowledge without regard to practical aims, why then should the government support basic research? An individual investigator may be working on a project with no other motivation than the desire to satisfy his scientific curiosity or to add a bit of knowledge to a field in which he is interested. The government, on the other hand, may be interested in his project to the extent of furnishing financial support because of the potential applicability of its findings to the solution of some larger problem. It is conceivable, also, that two federal agencies might support the same project for entirely different reasons. The National Science Foundation, for example, might support a given project in metallurgy for no other reason than that it gave promise of advancing the frontiers of knowledge in that particular area. The Department of Defense or the National Advisory Committee for Aeronautics, on the other hand, might support the same project because of its possible application to jet engines.

A fourth reason why the government should support research differs from the other three in that it pertains to other social needs. If, for example, the educational institutions of the United States should find themselves in financial difficulties that threatened to impair their ability to carry on their normal educational functions, then the national welfare might require some form of government assistance. To the extent that universities find themselves in this kind of difficulty, it is appropriate to ask whether the federal government should relieve the situation by providing financial support.

In Europe, government assistance to universities in varying degrees is an accepted social pattern, but Americans look askance at direct federal subsidy of their educational institutions. The tax-supported state universities and schools are regarded as a normal aspect of states' rights, but federal support is a different matter. It is not always generally appreciated, however, that tax exemption is a form of subsidy. Government support of research and development and government scholarships and fellowships are other forms of subsidy that may help to relieve the pressure, and such measures appear to be generally more acceptable than direct subsidization.

It is now generally understood that the government has a need for its own laboratories in areas where the work is not appropriate for industry or is not likely to be done under conditions that meet government requirements. It is altogether proper, for example, that the government should set and maintain standards of weights and measures and that there should be a national laboratory for this purpose—the National Bureau of Standards. Military research is the direct concern of the government, and arsenals and gun factories are among the oldest federal research establishments.

The most compelling reason for government support of basic research, either in or outside its own laboratories, is to assure continuing progress of

fundamental knowledge in science. In so doing, the government will not only serve its immediate foreseeable developmental needs but will also utilize science to the fullest extent as a national resource. An agency should, therefore, be free to establish and maintain such research under whatever conditions are most favorable to the satisfaction of its particular requirements. For this reason, it is neither feasible nor desirable for a single agency of the federal government to support all the basic research in which the government is interested.

Government support of research, like other large-scale efforts, is not without problems. Educators and administrators, for example, are increasingly concerned with the effects of government research work upon the normal teaching and research functions of our colleges and universities. The National Science Foundation is aware of some of these problems and feels that the impact of federal research upon our colleges and universities is a national problem that should be closely examined. The National Science Board has recently authorized the appointment of a committee, under the chairmanship of Mr. Chester I. Barnard, to consider the entire question. In addition to considering the effects of government funds upon the customary teaching and research activities of colleges and universities, the committee will also consider the question of how the federal government, in cooperation with the colleges and universities, may best develop and encourage research and education in the sciences.

Those who are close to matters of research realize that the role of government in basic research is a proper one and one that is likely to grow rather than to diminish in the coming years. It would be well if the public also understood and appreciated the significance of research in our national life, especially since, as has already been seen, science will continue to raise questions with which society as a whole must deal. In the entire question of the participation of the federal government in support of science, the concern should be to insure that the government's role is carried out in such a manner as to make possible the maximum benefits to be realized from wise policy and administration, and that any detrimental effects are understood and held to the minimum.

II. Scientific Research and the National Economic Potential

Anyone working in the field of research immediately recognizes that the terms *basic* and *applied research* define areas that in concept may differ but in practice shade one into the other. Research also is often confused with the engineering phase of development. It is obvious that research does not apply merely to the so-called sciences but applies equally well to unscientific, or perhaps more accurately, incommensurable material, as dealt with in the social sciences or the humanities.

It would be difficult indeed, if not impossible, to find any area of either thought or action that has not been affected and shaped by the results of research. Research, thus, is seen as a fundamental process by which the life of mankind, man's relationship to man, and man's relationship to nature evolves through time. Early work in arithmetic and geometry made possible the great structures of the ancients, which played such a vital part in their social and spiritual life. In more modern times, the work of Newton presaged the mechanical civilization which was shortly to follow, and now in current time is seen the work of such men as Hertz, Becquerel, Planck, and Einstein to bring forth a new civilization that is entering into what is popularly called, "the atomic age."

How do the discoveries of such great theoretical research workers affect the economic potential? Obviously, there are many links in this chain. Following the results from theoretical research efforts, there must naturally follow experimental verification. At this point new knowledge has become available, but it is still sterile insofar as the economic implication is concerned. Applied research next is effected and proves that such new knowledge will and can accomplish a useful purpose. This stage in turn is rapidly followed by the engineering application, which is called development. This step finally reduces the original knowledge to a useful economic factor, such as a new machine, a new material, a new process, a new product, or a new form of service. Out of such elements, the national economic potential is created.

The national economic potential can be interpreted as a nation's total capability. It includes capability to progress in a material sense, capability to progress in a moral and intellectual sense, and capability in a world of complex forces and pressures to maintain its own freedom, its own philosophy, and its own integrity. The standard of living is often considered to be the index of the national economic potential for any given nation. The term *capability,* as used here, is intended to have a broader meaning—that is, competence in all national aspects and relationships and not merely in material matters affecting the standard of living. The key role, and the predominant role, that scientific research plays in developing the na-

tional economic potential, therefore, becomes obvious.

Germany emerged during the period prior to World War I as a great industrial nation founded upon advanced technology. Germany, at that time, had insufficient agricultural resources and a lack of suitable minerals and other raw materials and was deficient in natural power resources. Yet with a population not much larger than its principal neighbors, and much smaller than its largest neighbor, it emerged as a leader in world trade. It had a constantly expanding standard of living, accompanied by many advanced forms of social progress. Its great chemical industry was a marvel of the world and had by research produced new drugs, new dyes, and many new materials and processes. Other technological industries were introducing new machinery and new processes that were the envy of the rest of the world.

How could a nation deficient in natural resources and limited in geography become such a dominant power in competition with other advanced nations? No simple answer serves the purpose, but an example will prove interesting. Although British and French chemists had formed the groundwork for the new synthetic chemical industry, the German nation was the first to exploit it. Its chemical industry employed the most enlightened methods of research in organized laboratories of greater size than could be found elsewhere at the time. German universities attracted leading scholars in the sciences from the entire civilized world. Theoretical and applied science, basic and applied research, and technical development all teamed together to overcome the economic disadvantages of a nation poor in natural resources. Germany, thus, provides an excellent example of the close relationship between scientific research and the national economic potential.

It was early in the 1800's that the United States gave to the world the concept of mass production. This followed naturally from a civilization that was built upon a generous inheritance of natural resources and suitable industrial manpower, the latter of which continued to flow in largely from the older countries of Europe. The adoption of mass production was destined to play a major role in the national economy and was undoubtedly one of the greatest of all technological developments. This technique, however, may be described more accurately as an engineering development than as one stemming from the process of scientific research. In 1902, the first research laboratory appeared on the American industrial scene. This was the General Electric Laboratory at Schenectady. America, however, continued to be the importer of foreign scientific ideas and technology. But it is generally conceded that the United States today continues to lead in the application of mass production techniques and that such methods are making a major contribution to the economic potential of the country.

Just prior to World War I, American inferiority with respect to the field of scientific research came clearly into focus. America had relied to a large extent upon the products of the great German technical industries for scientific instruments, precision optical systems, synthetic chemicals, and dyestuffs; and the deficiencies in the war effort proved that the economic potential was limited and lacking in a diversity of scientific resources. It has been stated that there were less than 10,000 physicists in the United States at that time. Various government bodies were created to survey the situation and organize the scientific talents of the country toward the common defense. For the first time, large industrial corporations became aware of the fact that, wittingly or unwittingly, they had depended upon the fruits of foreign research. Then followed the great expansion of research laboratories and the acceptance of the concept of scientific research. The literature of the period indicates that the word *research* took on some mystical significance and became a slogan for many things remote from the current concept of scientific research.

In the field of the national defense of the United States, the Industrial College of the Armed Forces in Washington, D.C., with the National War College and with the Joint Staff College at Norfolk, Virginia, constitute the highest educational facilities within the Department of Defense. All three organizations come directly under the cognizance of the Joint Chiefs of Staff and, therefore, embrace all the armed services. The very fact that the Industrial College was established on this high level of the military educational system is an indication of the importance that economics now plays in planning for the defense of the country. The Industrial College assigns a major group of its faculty and a portion of its curriculum to the role of technology. In this area of its studies, the concept of scientific research plays a key part.

It has been forced home on the leaders of the armed services that wars are won or lost on the basis of the national economic potential rather than on the current strength of the armed forces. The upper limit of effective mobilization, military strategy itself, and the allowable specific combat effort for any given operational area are directly

derived from the economic potential of the country. It has, therefore, become of vital importance to the preservation of the nation that its military leaders be taught to understand the function of technology and the basic role of scientific research in forming the economic power from which the logistic support of all combat operations is derived.

Referring to the growth of research in the United States, Fig. 1 illustrates the startling recognition of the function of research and its acceptance by government and by business in the last 20 years. This chart shows the extraordinary acceleration of research under the impetus of World War II, followed by the recognition of the importance of research in the period of the "cold war." The professional term *military posture,* as used today in diplomatic circles, reflects the contribution that scientific research has made.

The recent volume of David E. Lilienthal, *Big Business: A New Era,* states that the diesel engine was 30 years under research and development before coming into general use, and, likewise, that Du Pont's nylon was the product of 13 years of effort and an expenditure of more than 20 million dollars before the first bolt of material was marketed. It has been stated also that Monsanto's Krilium is the product of 11 years of research; and the modern gas turbine, well known in theory before World War I, became a factor for the first time in World War II, more than 30 years later. These examples are illustrative of applied research and development and are instances of specific applications, but the fundamental scientific developments from which they were derived long preceded them.

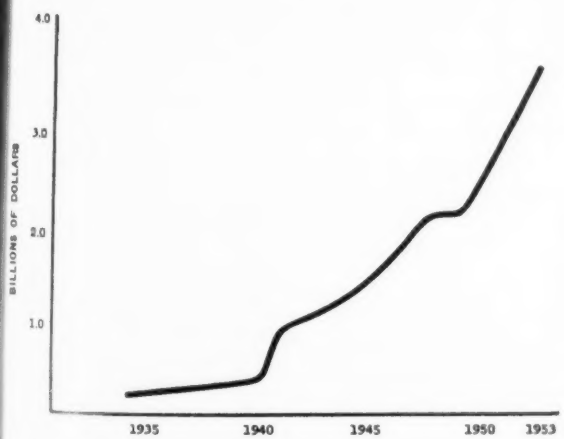


FIG. 1. Growth of research in the United States, based on estimates from the Research and Development Board and Steelman Report. (From a lecture by Clyde Williams, of the Battelle Memorial Institute, before the Industrial College of the Armed Forces.)

The sources and distribution of expenditures for research and development in the United States today, by agencies, are indicated in Fig. 2. One of

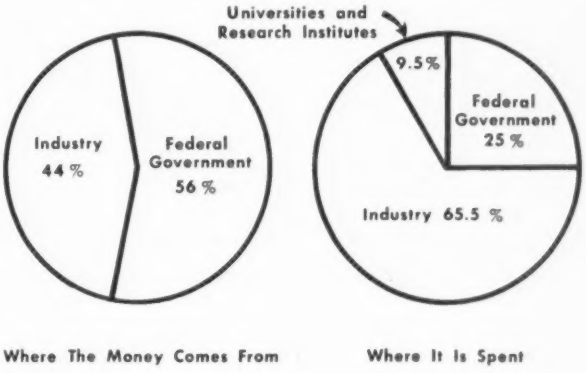


FIG. 2. Spending for research and development for the year 1952. (National Industrial Conference Board.)

the most important and significant developments in this field is the work that is done in universities and nonprofit research institutions. This effort, in 1952, amounted to 9.5 percent of the total; today, this percentage is considerably larger. The role of this group is relatively new and would hardly be apparent on any normal chart reflecting the total research done prior to the late 1930's.

A large American industrial unit in 1952 installed three vital new processing techniques, with all their equipment. One originated in Poland, one in Sweden, and one in Italy; these were the three most important new processing developments for the period in question. This adaptation is an example of American alertness to foreign research and technical development, the fruits of which, in nearly every instance, have subsequently been improved. The contribution to our own economy from such sources is often not adequately recognized.

Until very recently, only in the older civilizations was there to be found a natural encouragement for men of exceptional scholastic ability to pursue their theoretical studies in the cloistered atmosphere of universities. If the great fundamental scientific developments leading to the new atomic age are studied, it will be found that it was France, England, Poland, Germany, Switzerland, Australia, Denmark, and Italy which contributed the majority of the great theoretical ideas. This occurrence was in spite of the fact that the experimental effort and the final development of the end-products of all this research were first manifest in the United States. It should be added that, in general, big business is yet unaware of the key role that uni-

FIG. 3. Growth of research in the United States in billions of dollars. (Industrial College of the Armed Forces.)

versities must play in generating a favorable atmosphere in which exceptional scholars will work. These scholars are the men from whom will come the new scientific and philosophic concepts that will expand outward the boundaries of knowledge from which technological progress emerges.

Figure 3 indicates the extraordinary relationship between the growth of research in government relative to its growth in industry. *Research* is used in this chart comprehensively to include the social sciences, the life sciences, physics, chemistry, mathematics, and associated fields. In monetary terms, this illustration can be misleading, since the least expensive research is that which is solely in the realm of ideas, statistics, and philosophic concepts.

Figure 4 shows the gross national product of the United States in billions of dollars and the population growth of the country. It is not certain that a precise correlation can be made between such a curve and that of the growth of research as reflected in Fig. 1, since the relating factors are not simple and direct. It can be fairly stated, however, that the gross national product could not reflect the enormous growth represented in Fig. 4 without a corresponding effort in the field of research and development as indicated in Fig. 1.

Figure 5 illustrates graphically the quantitative comparison of the standard of living in a number of principal countries. A measure of the national economic potential of any country is based upon the total power available. Thus, the standard of living in any country can be shown to be coincident with the power available per unit population per year. The USSR ranks below the middle of the list but is making rapid strides forward from year to year. The statistics on trained scholars, engineers, and technologists in Russia today, as compared with the United States, and the emphasis placed by the Soviet government on industrial and scientific research readily indicate the relatively rapid progress in this field in the Soviet Union.

Figure 6 shows the remarkable correlation between the power output per unit population in the United States beginning in 1902 and that of the standard of living expressed in standard dollars for the same period. It is interesting to note the effect on the standard-of-living curve of the depression of the 1930's and the boom period of World War II in the 1940's. Except for these two major effects, the curves of the graphs are parallel throughout, and the conclusion might be made that the national economic potential, as well as the national standard of living, are each reflected in the power available per unit population per year. It should be evident that production results from available power and that new products result from research and development as well as do the methods and processes for their production.

The Du Pont Company has developed a chart, reflected in Fig. 7, that indicates the enormous contribution made by machine labor to the standard of living, the national product, and, hence, to the national economic potential. A century ago the national economy reflected almost entirely the physical work of men and animals. Today, it is approaching the forecast ideal of the year 2003, when it will be based almost wholly on the machine.

The contribution to the economy of the nation by the technological development of materials has been important in the recent past and will continue to be so in the future. Many new organic products are now available to industry. The new technology of chemurgy, for example, may prove to be the

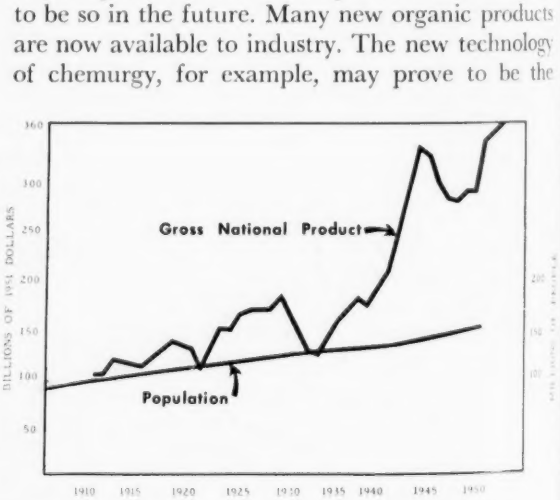


FIG. 4. Gross national product of the United States in billions of dollars and the population growth of the country. (Industrial College of the Armed Forces.)

answer to many of the problems raised by the Paley Report of the President's Materials Policy Commission in its study of the resources for the future. Other examples of new fields of technological development with tremendous implications for the future are atomic power, coal hydrogenation, oil shale extraction, radiation synthesis, and ultrasonics. All these fields will depend upon research and development for their realization.

It would be impossible to overemphasize the importance to man of the atomic age. Dr. Farrington Daniels, of the University of Wisconsin, has pointed out the limited natural resources of the world and their degree of exhaustion as civilization builds ever higher levels of living. It is stated that there is estimated to be 23 times as much atomic fuel suitable for energy available in the earth as there is the sum total of all the fossil fuels of oil, gas, and coal. The Paley Report forecasts in a dramatic manner that by the year 2023 mankind will have insufficient sources of fossil fuels to maintain civilization in the standard of that time. How better can the role of research and development be portrayed than to show that it alone can resolve this dilemma?

Modern cosmologists point out that the earth is roughly 2½ billion years old. The earliest remains of man are indicated to have been discovered a little over 15 years ago and to be approximately 1 million years old. Civilization is recorded only

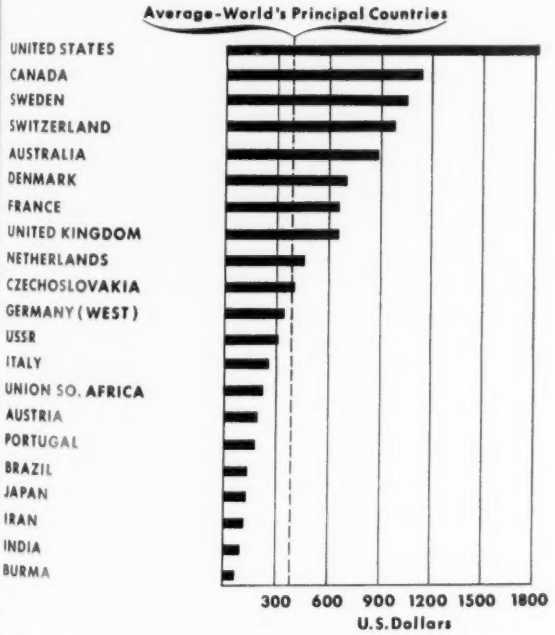


FIG. 5. Per capita income in various countries for 1951, in equivalent U.S. dollars. (Industrial College of the Armed Forces.)

FIG. 6. Standard of living compared with available energy per unit population. The left-hand scale represents constant dollars of gross national product per capita. The right-hand scale represents kilowatt hours per capita.

for the last 6000 years. Yet the cosmologists relate that the atomic cycle of the sun forecasts 6 billion more years of suitable climate on the earth in which mankind can carry forward his evolution and his existence. How could even a minute portion of this God-given future be utilized for the betterment of man without an accelerated and continuing emphasis on the role of research and development?

III. The Contribution of Industrial Research to National Security

It is the tragedy of the time that our nation's primary concern is with its security. The Communists, dominated by the Kremlin of Moscow, are attempting to destroy the governments and social structures of the free world through threat of an all-out war, while at the same time attempting to attain their goal through so-called "cold war" techniques of their creation.

America can remain free and be secure only if it protects itself from both of these techniques aimed at its destruction. The nation's program for its protection is the building of a military potential of great strength while maintaining a healthy and expanding economy. A military strength of such obvious effectiveness is being created that it should deter the Kremlin from seeking to attain its goal

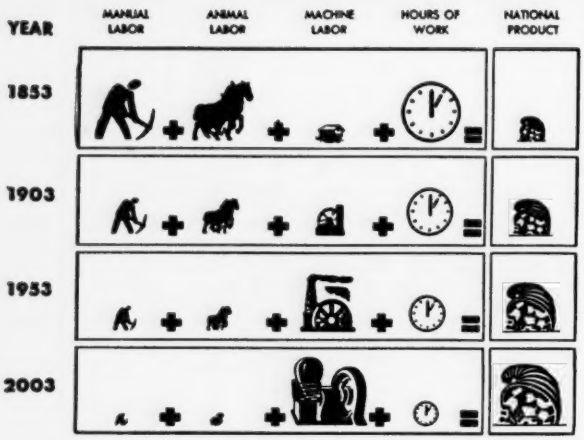


FIG. 7. Increasing contributions of the machine to the national product. (E. I. du Pont de Nemours & Company.)

by the military route; however, should the Kremlin, through plan or accident, precipitate a war, the free world should be the victor. While building this strength, America is maintaining a healthy and expanding economy in which all citizens share its social and economic benefits. This structure offers protection from the "cold war" tactic in which the Kremlin hopes to "bore from within" by building internal Communist revolutionary strength in an atmosphere of economic chaos where a significant number of the citizens are in the mood for a radical change in the pattern of society.

Industrial research contributes to national security through its application of scientific knowledge in the military area to the creation of new weaponry and in the civilian area to the creation of new facilities of benefit to the economy and to the enrichment of life. Other research laboratories of the nation join with those of industry in this contribution. The laboratories of government, of academic institutions, of foundations, and of industry are increasingly joined in unified research programs. Their contributions to the military have made our nation the arsenal of the free world and the leader in the struggle to maintain its security. At the same time, their output for the civilian area is basic to an abundant and expanding economy.

The statistics of the current dollar volume of the nation's basic and applied research effort are most impressive; in fact, their magnitude is astronomical. The contributions to military strength and to the civilian economy that this level of expenditure produces are even more impressive. The nation applied only a negligible fraction of its basic and applied research strength to new weaponry before 1940. During the period 1940–1945, research laboratories made revolutionary changes in the character of warfare. *Radar, sonar, proximity fuse, acoustically homing torpedo,* and *atomic weapon* are terms that were completely unfamiliar in the 1930's. These terms, along with many others, are descriptive of the new weaponry that was created by research talent and were produced by industry in World War II. Without question, their application to warfare hastened victory with a saving of American lives.

Since the close of the war, the nation's laboratories have continued their application of scientific knowledge to improved weaponry. The weapons of World War II were still in their pioneering stage at the close of the war; they have been greatly improved and new weapons are constantly added to our arsenal. The advances have been most significant in atomic weaponry and the mechanisms and methods of their delivery. Their combined effectiveness is appalling. A variety of atomic-weapon types ranging in destructive power from the tens to the hundreds of kilotons of TNT equivalence are now available. Methods of delivery ranging from supersonic piloted bombers through electronically guided missiles to rockets and cannon are either in being or near at hand. The military effectiveness of the atomic warfare that these new weapons and their methods of delivery have generated is given such a high effectiveness rating that, in the current planning for defense in the years immediately ahead, significant reduction in manpower is contemplated with no sacrifice in military strength.

The contributions of basic and applied research to the civilian economy are important in the maintenance and preservation of the free society that has evolved under our capitalistic system of democracy. If the social and economic structure of a society provides its people with a good life, with not too great variation in its quality from the bottom to the top of its structure, and accompanies this with a reasonable amount of leisure for all, the overwhelming majority of the members of that society are then content with it as a framework within which to live. Conversely, if the economic and social structure of a society fails in providing this environment, then a significant number of its members are discontented and ready to turn to another structure of society that gives promise for such an environment. In countries where the latter condition prevails, the Communists have been, to varying degrees, successful in promoting their philosophy and creating a desire for revolution.

The quality of living of the people of America is at the highest level in the world. This condition

has been attained while the hours of work to provide it have steadily decreased. Increasingly with time, its richness has been extended to all members of society. Differences in quality of living from the so-called top to the bottom have been steadily narrowed, while the level of all has been raised. There is, thus, an environment that is unfavorable to the Communist, and he has had in fact little success in having his revolutionary philosophy accepted. These qualities of society are of great importance to national security. A military potential of maximum strength will not suffice for the preservation of free and democratic society unless it maintains and gradually enhances the qualities of living of all its people. The nation's basic and applied research is, perhaps, the most essential of all the elements that contribute to these qualities of American life.

Two examples will illustrate the operation of applied science and technology in the rise of the standard of living. Agriculture is chosen as the first, since it is basic to existence. In the past 30 years, the food production of the world has increased by less than 10 percent, while the population has expanded about 30 percent. In the United States, while the population has increased about the same amount, food production has expanded more than 50 percent. This rise has been accomplished with substantially no increase in farm acreage but with a significant decrease in farm population. Thirty years ago the farm population was some 30 million. By 1950 it had decreased to some 24 million, and the farmer's hours of labor have significantly decreased.

The increase in food production with a decrease in man hours required and with the utilization of substantially the same farm acreage has been made possible by the application of scientific knowledge to the food-production problem through applied research and technology. Mechanization of the operations of farming played an important role. With the increasing effectiveness of cultivating machinery, the tractor and its driver can cultivate, and more effectively, in excess of double the acreage formerly done by two horses and a man. The energy for driving the tractor is oil, a mineral product, while the energy for sustenance of the horse had to be obtained from the acreage it cultivated. In 1952, farmers purchased about 100,000 power machines as aids in their ever more efficient food production.

The applications of chemical knowledge have been at least as effective in increasing the efficiency of food production as has mechanization. Fertilization of the soil by a variety of relatively low-cost chemicals increases the productivity of the soil. A great variety of organic chemicals are also used, such as herbicides, soil conditioners, fungacides, defoliants, growth regulators, and insecticides. The names of these chemicals are adequately descriptive of their use. Thirty years ago most of them did not exist. Farmers purchased some 400 million dollars' worth of these chemical products in 1952.

The chemical industry is the source of the fertilizers and the organic chemicals for a variety of agricultural applications. It is one of the younger industries and is, perhaps, the fastest growing. Its contribution to national strength through aids to civilian economy and to the military are of growing importance, for, as the natural products of the inorganic world become depleted, it is to organic chemistry that we must turn for the essential materials of industrial society. Research and development are the cornerstone of this vital industry; scarcely a year passes when each of the dozen or so larger chemical companies, through their research and development programs, do not add from 10 to 15 new products for the industrial or consumers' market. Forty percent of chemical sales is accounted for by products that did not exist 15 years ago. In 1937, the sales volume of the products of the chemical industries was about 700 million dollars, while today it is in excess of 4 billion.

The chemical industry, among its many contributions to military strength, has given distinguished service to the government in using its management, research, and engineering strength in the development of plants and their technical processes, and then in operating the plants for production of products essential to military needs. Synthetic rubber, fixed nitrogen, and processing of uranium ores are typical of the specialized government-owned plants to which the chemical industry has contributed so much of management, research, and engineering talents. Chemical research, in which that of industry is the largest element, is vital to national security in the military and civilian areas.

The second example of applied science and technology is taken from the service industries. Communication is becoming increasingly important in the nation's economic and social life. Thirty years ago the Bell System, which supplies a little more than 80 percent of the nation's telephone service, served some 8 million telephone subscribers. Today, its service is used by about 41 million subscribers. While the number of stations has increased fivefold, this fact is an inadequate measure of the increase in service that the System provides. Thirty years ago, because of limitations imposed by technology, the distance of telephone communication

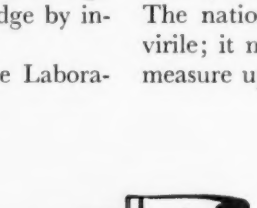
was severely limited in comparison with today. The conversation of most subscribers was restricted to an area perhaps not more than 50 miles in radius, although a limited number were beginning to talk across the continent. Today, through telephony, the entire nation has become a neighborhood. The extended area of use of telephone service has grown to such proportions that the development of nationwide subscriber dialing to provide more rapid and more economic service is well advanced. When these facilities are nationally installed, any subscriber in the nation will be able, through dialing, to interconnect with any other subscriber in the nation. The range of telephony is not restricted by national borders. With the aid of Bell System transoceanic radio telephone circuits, any subscriber may be connected with most of the 33 million subscribers beyond our borders. Bell System service has also been extended to record communication where a teletypewriter can "talk" to any other teletypewriter anywhere in the country. National radio and television program circuits distribute programs to the hundreds of radio and television broadcast stations throughout the land.

This fivefold increase in telephone stations, enhanced long-distance service, and new record and broadcast service are all supplied with only a threefold increase in number of employees in the operating companies of the Bell System. Some 30 years ago, there were 225,000 such employees, while today the number is approximately 600,000. The fivefold increase in number of people served, the improvement in quality and the extension of service, and the new services have been realized with only a threefold increase in operating personnel through the application of new scientific knowledge by industrial research and technology.

The Bell System at its Bell Telephone Laboratories maintains a large research and development organization for converting new scientific knowledge into new telephone technology to make possible more economic, improved, and extended telephone service. The growth and increased scope of telephone service that has been described has been possible only through this conversion of scientific knowledge into technology.

Telephone technology has much in common with that of new weapons systems, particularly in their automatic guidance and direction. Bell Laboratories, along with the other communications and electronic laboratories of the nation, have made large contributions to the development of weapons systems. In the period since 1940, for example, almost one-half of Bell Laboratories expenditures has been for research and development for the military. Weapons systems of great variety have resulted from this work and have been produced for the military in dollar volume well in excess of 4 billion.

The basic freedoms and the cultural values that the individual of the Western World enjoys are now threatened by the dynamics of Communism to a greater extent than at any time in the history of Western civilization. Our nation, with its great strength and dedication to freedom, must lead and make the largest contribution in the preservation of these values inherent in Western society. The continued security of America is vital to this leadership and contribution. The research of the nation is essential to the maintenance of this security. Industrial research is carrying out some two-thirds of the research program. Looking to the future, its responsibilities are increasingly great. The nation's industrial research is strong and is virile; it may be assumed that it will continue to measure up to its responsibilities.



The Grinning Crocodilian and His Folklore

CLIFFORD B. MOORE

The author, director of Forest Park Museum, Springfield, Massachusetts, holds an M.A. degree from New York University. His recent book, Ways of Mammals, is generally regarded as the standard authority on the folklore of our quadrupeds. Mr. Moore is currently collecting and evaluating material on reptile and amphibian folklore for publication in book form at some future date.

YOUNG Florida alligators, at the tender age of one or two years, are sold in large numbers as souvenirs and are then brought north by tourists as family pets or for the entertainment of relatives and friends. Needless to say, when the novelty of having one of these unresponsive and apathetic creatures wears off, the nearest natural history museum or zoo is called and the offer of a new alligator is made.*

A week after the doors of our own museum were thrown open to the public, a women visitor brought in a crocodilian offering for the small but up-and-coming live animal gallery. After boarding the animal in her bathtub for two weeks, she decided that family cleanliness came first and that the 'gator must go!

We are appalled by the thought that, had our museum accepted all the alligators generously proffered by the public during the past decade, we would now have close to one hundred crocodilian guests receiving board and keep. To maintain such a mammoth menagerie, an enclosed steam-heated jungle garden would have to be constructed. Moreover, the food bill would be staggering in so far as our modest budget is concerned, and a small corps of men and boys would have to be kept in the field each summer collecting live fish, frogs, and sundry other delicacies that delight the palate of hungry young crocodilians.

Concomitant with the maintenance of young alligators in a museum or zoological garden are the hundreds of inquiries made by the visiting public in the course of a year concerning the behavior and physical peculiarities of the animals. Probably the most frequent question is, "What will you do with the alligators when they get big?" This question bothers us no end, and we cannot easily visualize our little community of six alligators, grown to ten or twelve feet and swimming about in a large pool in the limited confines of the old New England mansion that has been converted to museum use.

The idea prevails that alligators always grow very slowly. Typical of this is the statement made in 1900, by Hugh M. Smith of the U. S. Fish Commission: "Alligators grow very slowly. At fifteen years of age they are only two feet long. A twelve-footer may be reasonably supposed to be seventy-five years old."

In their natural habitat in the hot, humid Florida Everglades and in certain other localities in the Gulf States, and with an abundance of food, alligators actually grow rapidly. They may attain sexual maturity in six or seven years or when less than eight feet in length. A seven-foot female was known on one occasion to deposit thirty-seven eggs. Although alligator growth continues after maturity, it gradually diminishes. If a thirteen-foot specimen is encountered today in the wild state, it is indeed a rarity.

Raymond L. Ditmars made extensive studies of alligator growth and development, both in the reptile's natural habitat and in the zoo. From one clutch of eggs of the American alligator that he collected came young whose average length at five years was five and a half feet. "A specimen in the

*To protect the breeding stock of the alligator in Florida and to check overhunting, the state is enforcing a new law. Certain important provisions of this law are stated briefly as follows: alligators eight feet or more in length may be taken from October 1, 1953, through the last day of January 1954; ten counties in the state are closed entirely to the collecting of alligators; ten days are provided following the close of the season for disposition of hides taken legally; shipment of alligators and their hides by common carrier is prohibited except on permit from the Game and Fresh Water Fish Commission.

It is said now that certain Florida pet dealers are, as a substitute for the native alligator, importing and stocking up on South American caimans for tourist sales and for use in their mail order business.

reptile house of the New York Zoological Society, measuring exactly seven feet," he noted, "grew to a length of 10 feet, 11 inches in five years' time." It should be added here that temperature and humidity in many zoological park reptile houses, including New York's, are carefully controlled, with the result that those conditions conducive to alligator growth are usually present. On the other hand, those young 'gators brought into northern homes and maintained as pets, under markedly artificial conditions, do not develop normally. They become sluggish and often refuse to eat the raw hamburger imposed on them by kindly intentioned owners. Consequently, if they grow more than three inches a year, it is, to say the least, unusual.

The family Crocodilidae comprises some twenty different species. Within this group, only two species of alligators are known. *Alligator,* the generic as well as common name, is a corruption of *el lagarto* (meaning the lizard), a name originally conferred upon the reptile by sixteenth century Spanish explorers and settlers in North America, who concluded that the creature was a huge lizard when they first observed it. The Chinese alligator, which inhabits the Yangtze-Kiang River and its environs, was brought to the attention of the world in 1870 by the explorer-naturalist Swinhoe.

It is a popular belief in North America that all crocodilians are man-eaters and that they take a fiendish delight in stalking any person who ventures into a jungle pool or river. This impression is continually conveyed to us by movies of the adventure type. We know of no authenic records of the American alligator killing human beings, but we do believe certain large individuals might be sorely tempted to attack a man if he audaciously goes bathing in their haunts. The real man-eating crocodilians, if they may be so called, are the salt-water crocodile (*Crocodilus porosus*) of Asia and the Pacific Islands* and the African or Nile crocodile (*Crocodilus niloticus*).

The crocodilian diet is comprised mainly of fish, frogs, snakes, and crustaceans. An alligator will avidly snap up any small mammal unfortunate enough to get within the range of its powerful jaws and tail, and wading birds and waterfowl are occasionally taken unawares and consumed.

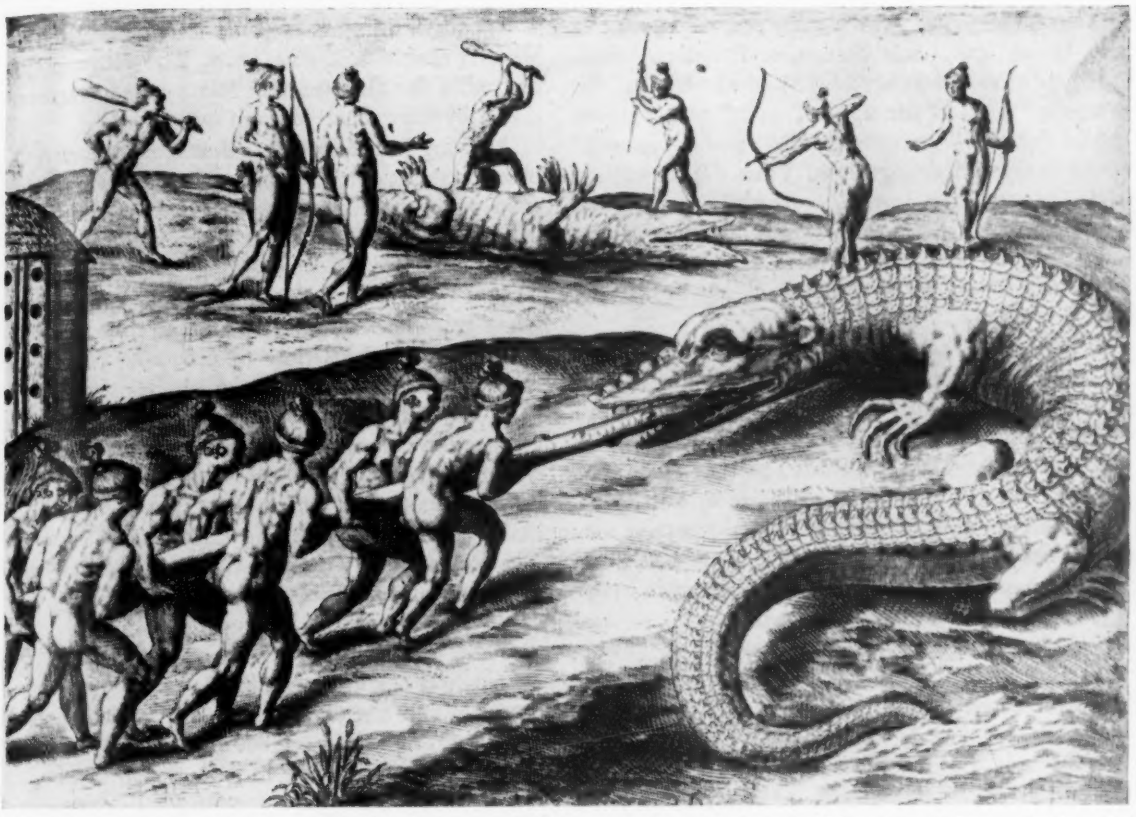
Floating motionless in the water for extended periods with only their nostrils, eyes, and a small part of their backs exposed above the surface, crocodilians may prove a real menace to many kinds of animals that come down to the water to drink or to bathe. The fatal error is to mistake the reptiles for floating logs. In addition to its utility value as an instrument of propulsion, the crocodilian tail is a formidable weapon of offense. One well-directed lateral blow with that member will easily knock a man off his feet, or any medium-sized quadruped that inadvertently gets within range. When a victim has been captured and rendered *hors de combat,* through immersion, crushing of the body, and nervous shock, the crocodilian comes to the surface to eat. Small animals are swallowed whole, but large ones may be torn into a number of pieces convenient for swallowing, in a tug of war by several crocodilians. Although several writers of recent popular books about animals state categorically that the carcasses of large animals are hidden and left until the flesh decomposes and becomes soft, we are inclined to view such an activity on the part of crocodilians with doubt. The storing away of food for future use has never been reported as a confirmed crocodilian trait by competent students and observers of the reptiles; moreover, we believe that many kinds of animal scavengers would quickly locate and convert to their own use any cached food.

The tongue of a crocodilian is fleshy and non-protrusible. Because it is attached to the floor of the mouth except at the extreme edges, it is somewhat inconspicuous as tongues go, hence the old belief that the reptiles have no tongues.

The eminent Greek historian Herodotus, in the fifth century A.D., did considerable traveling in the countries bordering the Mediterranean. In the potpourri of beliefs and the details of information he collected and recorded of the crocodile (Book II, section 68) is the remarkable statement that "it does not move the lower jaw, but is the only animal that brings down its upper jaw to the under one." This misconception has had a long and tenacious existence, and the identical statement appears in a current circular of a Florida "alligator farm" where it is cited as a means for distinguishing crocodiles from alligators. The following brief but significant comment is offered by Karl P. Schmidt: "If one views an open-mouthed crocodile (or an alligator, for that matter) with entire oblivion to the facts of anatomy, it may indeed appear that the upper jaw is opened instead of the lower. The slightest observation, or even reflection, would prove that this is an appearance only, and that the lower jaws of crocodilians are hinged to the fixed remainder of the skull as obviously as in ourselves."[1]

In his account of the crocodile, Herodotus also alludes to the "tolerant relationship" that exists

* *C. porosus* has an unusually extensive range which embraces India, Ceylon, and southern China, the Malay Archipelago, including the Solomon Islands, and North Australia.



How they hunted crocodiles in Florida. This copperplate engraving was done by Theodore de Bry in 1591 and is included in Volume II of his *American Voyages*. It is the first illustration of the American crocodile (*Crocodilus acutus*) known to have been published and is based upon an earlier sketch by Jacques Le Moyne, a professional French painter who joined a Huguenot colony in Florida.

between the Nile crocodile and Egyptian plover (or courser), often referred to as the crocodile bird. Standing on the reptile's upper jaw the feathered "companion" fearlessly picks and eats fragments of food that have lodged between its teeth. The bird likewise performs yeoman service by feeding upon parasitic leeches that attach themselves to the more tender skin about the crocodile's mouth and neck.

In his quaint zoological treatise, *The Historie of Foure-footed Beastes* (1607), Edward Topsell writes that the "little crocodile bird affecteth and followeth this for the benefit of his owne belly," and that it "cleanseth the teeth thoroughly, for which cause the Beast is content to permit the Bird to goe into his mouth." He further states that "when all is clensed the ingratefull Crocodile endeavoureth suddainly to shut his chappes together upon the Bird, and to devour his friend." The gross misinterpretation and distortion of facts that characterize this traveler's tale by Topsell gives one the impression that the writer was striving desperately to weave color, curiosities, and marvels into an otherwise prosaic texture of plain fact. Such would seem a small concession to publishers and the reading public of the time who were not altogether content with precise fact but looked for, and were intrigued by, the extraordinary.

It is interesting to note that, according to Pliny, the first crocodiles ever seen in Rome were five specimens imported from the Nile and exhibited in the menagerie of one Scaurus, about 28 B.C. We read also that in the days of Augustus, for the benefit of the populace who received its excitement vicariously, thirty-six crocodiles were introduced into the arena where they were summarily dispatched by gladiators.

Beyond doubt, the most venerable item of crocodilian folklore concerns the shedding of tears with an accompanying moaning and groaning like a person in distress. Thus the sympathetic but unwary wayfarer, attracted to the scene of sorrow, finds himself precipitately seized in powerful jaws with tragic results. Not only may the tears be shed as a lure for human victims, but they may also be exuded out of sympathy for the crocodilian's prey, about to be devoured or, perhaps, already consumed.

"Crocodile tears" was a common expression in both Greek and Latin literature. Polydore Virgil, in his *Adagiorium Liber* (1498), declared that the crocodile "wept at the sight of man," and, causing him in this way to approach and view the unusual spectacle, would devour him. Thus the expression crocodile tears (*Lachrymae crocodili*), was applied in a proverb to those who falsely arouse the pity and charity of men. "She's false, false as the tears of crocodiles," wrote Sir John Suckling in his play *The Sad One* (1639).

In *Adagia,* Erasmus (1466?–1536) quotes both the Latin and Greek forms of the proverb, and in his *Colloquy on Friendship* he gives a story from Aelian's *De Animalium Natura,* written in the early part of the third century, to the effect that the crocodile fills his mouth with water and ejects it to make the path slippery for his prospective victim. Erasmus further explains that crocodiles macerate the heads of their victims with tears in order to soften them for easier swallowing.

Sir John Mandeville, in his *Travels* (*ca.* 1371), among numerous other amazing phenomena, relates that in India "the cocodrilles sley men, and eate them weeping, and they have no tongue." The same fable is repeated in the account of Sir John Hawkins' voyage (1565), and malodorous comparisons are made there between the tears of the crocodile and those of women.

Edmund Spenser (1552?–1599), in his celebrated epic, *The Faerie Queene* (Book I, Canto 5), wrote:

> As when a wearie traveiler, that strayes
> By muddy shore of broad seven-mouthed Nile,
> Unweeting of the perillous wandring wayes,
> Doth meete a cruell craftie Crocodile,
> Which in false grefe hyding his harmeful guile,
> Doth weepe full sore, and sheddeth tender teares;
> The foolish man, that pities all this while
> His mournefull plight, is swallowed up unawares,
> Forgetfull of his owne that mindes an others cares.

And in *King Henry the Sixth* (Second Part, Act III, Scene 1) of Shakespeare, we hear Queen Margaret describe her spouse as being:

> . . . Too full of foolish pity; and Gloster's show
> beguiles him, as the mournful crocodile with sorrow
> snares relenting passengers. . . .

It is true that the crocodilians shed tears, but the secretion is purely involuntary on their part. Individual alligators can do little in the way of tearing their food into smaller portions, and we have noticed on different occasions that while one of our museum specimens strained to swallow an especially oversized fish or frog, a number of large tears would run from its eyes and down its "cheeks," if the jugal region might be called cheeks. These were veritable crocodile tears. The alligator (and crocodile, for that matter) has a tear or lachrymal gland in the corner of each eye.

A strong possibilty exists that early travelers and observers came to associate the lachrymal secretions of crocodilians, surfeited and choking with food, with some supposed emotional facet of the reptile's nature. In attempting to ingest an overlarge piece of steak at dinner one evening, and while gasping desperately for breath, we were conscious of a copious flow of crocodile tears. Most readers probably can report similar experiences.

In one early Bestiary we find the statement: "If a crocodile comes across a man it kills him, but it remains inconsolable the rest of its life." We are, however, not enlightened as to why the reptile remains inconsolable for the remainder of its days. The anonymous writer of this medieval and allegorical treatise on beasts describes the hydra as "a very wise animal who understands well how to injure the crocodile." The *modus operandi* is quite simple, and the injury inflicted seems beyond question. "When the hydra sees the crocodile go to sleep it covers itself over with slimy mud, and wriggles into the crocodile's mouth, penetrates into its stomach, and then tears it asunder."

The dolphin appears to be another foe of no mean potentialities. Pliny relates that when these mammals desire to pass up the Nile, the crocodiles, who regard the river as their particular preserve, greatly resent their presence and endeavor to repulse them. As the dolphins (so the story goes) fully realize that they are no match for their foes in a fair fight, they take refuge in their superior maneuverability and speed, and having a dorsal fin as sharp-edged as a knife, they swim swiftly beneath the crocodile and, since the belly of the reptiles is unprotected by hard scales or armor, they rip the crocodile open with a single well-directed thrust!

The crocodilians have vocal accomplishments that have been variously described as roars, grunts, bellowings, and mournful howlings. Some of those grunting sounds emitted by alligators, both in the wild and in captivity, concern the matter of food. Thus when the temperature rises to a comfortable 80–85° F, alligators in captivity may evince a lively interest in food and commence to grunt. However, this grunting cannot in any way compare to those grandiose, awe-inspiring roars delivered by big bull 'gators during the spring breeding season. On a calm, warm night in the swamps and bayous, the roar of a romancing bull can be heard almost a

mile away. One reporter of Colonial natural history, John Lawson (1709), said of alligators: "They roar and make a hideous Noise against bad Weather, and before they come out of their Dens in the Spring—a sound loud enough to shake a house."

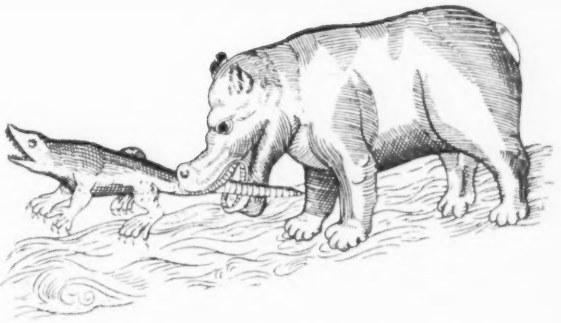
Although the evidence is not conclusive, it seems to be generally agreed that bellowing among alligators is done only by the males. When one bull begins to sound off, other individuals in the vicinity may join freely in the chorus. Several theories exist as to the purpose or role of alligator bellowing. One school of thought interprets it as a mating call whereby the female is attracted and drawn to the bull. An opposing school of thought insists that the roar has no special attraction or significance for the female, but merely serves as a warning and challenge to possible rivals who might encroach on the breeding area to gain the attention and favor of females.

The hissing sound produced by crocodilians is apparently a reaction to stimuli of annoyance. It is the result of the exhalation of air, and we have observed on numerous occasions that even when young alligators hiss, many of our museum visitors are apprehensive, if not intimidated.

Because crocodilians have comparatively good hearing, a perplexing question in the minds of many people concerns the whereabouts of their ears. This problem was a vexatious one to alligator hunters who often resorted to grunting in order to draw the creatures from cover. Actually the relatively large tympanic membrane or "ear drum" is concealed by a flap of skin and tissue that serves as a valve. When the alligator swims submerged, the muscular flap closes tightly, presumably excluding water. But when the reptile emerges, the muscles relax and a slit is discernible. The alligator may at this time vibrate its flaps, probably to shake off any water that remains on them.

Alligators evidently hear both under the water and out of it. Undoubtedly the sunken position and the flap provide the protection necessary for such a large tympanic membrane. Its size is associated with an auditory sense more acute than that found in most other reptiles.

Some students and observers of the alligator claim that the secretion from the so-called scent glands of the reptile enables others of its kind to trace it through the water. In other words, by means of these glands, which are possessed by members of both sexes, it is possible for crocodilians to locate one another by the scent left behind. Although alligators presumably use the scent glands as an auxiliary medium of communication, it is not



An unpleasant affair in an African river. This illustration was used by Topsell in his *Historie of Foure-footed Beastes* (1607). Perhaps the hippopotamus shown here is merely annoyed at the crocodile's intrusion in his favorite swimming hole, but if this particular "river horse" is supposed to be devouring the crocodile, it must indeed be an exceptional beast, for actually the hippopotamus is no carnivore.

definitely known whether the secretion finds its greatest use in the water. One pair of the alligator's scent glands lies within the cloacal slit and is not visible from the outside. Another pair of the glands is situated on the inner side, right and left, of the lower jaw, and has a slitlike opening on the outside of the throat, which is readily visible from below and leads into a pocket where the secretion from the glands is collected.

From the days of the early settlers in America a distinctive odor has been ascribed to alligators. This has been variously described as fragrant, musky, fetid, and objectionable. One Colonial traveler in Louisiana wrote: "One cannot imagine how much the stench of the urine and excrements of the caymans infects the air along the Red River."[2] But on the other hand, and from another source, we learn that the odor of the alligator or "crocodile" is fragrant and not at all unpleasant.[3]

We have been in close proximity to adult alligators at all seasons and can say with assurance that our olfactory senses were never assailed by alligator odors. And, more specifically, we have not been able to detect any odor from the scent glands, although the reptiles are doubtless able to detect it among themselves. In discussing the matter, one naturalist who has guided numerous parties of tourists and sportsmen through the Florida haunts of the alligator points out that members of his groups, on various occasions in the spring, mistake the strong and not altogether sweet odor of flowering wild cherries as well as other plant life for alligator odors. Certain individuals, he said, refuse to be corrected in the matter and insist that botanical processes are animal manifestations.

The most striking characteristic of an alligator's

physiognomy is a capacious mouth set in what might appear to be a perpetual leering grin, as if in derision of his unhappy prey. The concept of the grinning crocodilian originates from the fact that the "lip" lines of the jaws are curved several times. Thus when the mouth is even slightly open and the long rows of teeth displayed, the suggestion of a human smile is strong. Of the Nile crocodile, we note in Lewis Carroll's household classic, *Alice's Adventures in Wonderland*:

> How cheerfully he seems to grin,
> How neatly spreads his claws,
> And welcomes little fishes in,
> With gently smiling jaws.

The crocodile apparently played a unique role in the affairs and religion of the ancient Egyptians. Several hundred mummies have been disinterred by archeologists in catacombs and tombs at Thebes. Herodotus noted that:

> Among some of the Egyptians the crocodile is sacred, while others pursue him as an enemy. The inhabitants of Thebes and those on the shores of Lake Moaris regard him with veneration. Each person has a tame crocodile; he puts pendants of glass and gold in its ear-lids, and gives it a regular allowance of food daily. When it dies it is embalmed, and placed in the sacred repository. But the inhabitants of Elephantine eat the crocodile, not at all regarding it as sacred.

The stomach of crocodilians is fashioned somewhat like that of birds, with an imperfect division into crop and gizzard. As do many birds, all crocodilians have the habit of swallowing hard pebbles. This apparently aids in digestion. There is an old myth that the Nile crocodile swallows a pebble on each of its birthdays, thus giving reliable information as to its age by the number found in its gizzard at the time of its death. The habit of swallowing pebbles has also been suggested for some of the most ancient crocodiles, the teleosaurs, on account of the recurring presence of siliceous pebbles found with the remains of their skeletons. Pebble swallowing was also characteristic of the plesiosaurs, with whose remains stomach-stones, or gastroliths, as they have been called, are often found.

Until the practice of medicine became firmly established on a scientific basis after the middle of the nineteenth century, the crocodile, in common with various other forms of animal life, was a source of numerous remedies for the treatment of human ills. A compilation of medicinal properties and uses of the reptile, taken from a number of sources in both Europe and America from 1600 to 1800 indicates, for instance, that the blood was a sovereign remedy in the treatment of snake bite, specific diseases of the eye, and the general impairment of vision. The fluid and ground tissues of the crocodile's gall found especial favor in ophthalmological practice. A portion of crocodilian flesh, some authorities recommended frying it first, when eaten or applied to a wounded or painful part of the human body was believed to relieve the symptoms and bring about a permanent cure. "The skinne of the Crocodile," wrote one seventeenth century authority on materia medica, "dryed into powder, and the same powder, with Vineger or Oyle, layd upon a part or member of the body, to be seared, cut off or lanced, taketh away all sense and feeling of paine from the instrument in the action." The surgical patient of other days must have had remarkable fortitude, as well as faith in the virtues of crocodile flesh, to allow his operation to proceed along such lines of anesthetization.

In Egypt, as well as in other Mediterranean countries, a "rubdown" or external application of the suet or fat of the crocodile was highly approved as a treatment for fevers. We can never believe, however, that the continued application of crocodile dung to the human scalp was accepted with any great enthusiasm by those whose hair was falling out, yet this was a highly recommended and respected form of therapy at one time.

The belief is almost universal among the less sophisticated, in all lands inhabited by crocodilians, that their teeth are efficacious against poison, disease, witches, and bad luck in general. Crushed into powder, the teeth form the basic ingredient of numerous medicines to counteract poison. Among various Indian tribes in South America, a caiman tooth pressed against a snake bite site is regarded as a sure cure. In former times and among our own southern Indian tribes, an alligator tooth worn about the neck was no mere ornament but was a powerful charm in repelling venomous snakes. Even today, among our southern Negroes, alligator teeth form an essential part of the conjure bag. And, like the sorcerers of New Guinea in their magic practices, the American Negro finds an important use for the alligator in his voodoo rites.

A more commonplace and far less colorful use of crocodile teeth concerns the human toothache. One of the reptile's teeth was carried about by the person so affected and, through the inscrutable powers of sympathetic magic, the ache supposedly would be transferred from the human tooth to that of the crocodile. The tainted member was then buried.

From one reporter of Colonial natural history, we learn that if the hide of an alligator is pitted with bullets, the cavities might receive the falling seeds of the willow, sycamore, cottonwood, and

other riverside trees while the reptile hibernates in the mud. The seeds are then supposed to germinate and take root between the hide and flesh; and when the alligator revives in the spring, his underwater movements are revealed at the surface by little green shoots.[4] This particular myth is quite original in so far as American crocodilian beliefs go. For the most part, Colonial writers seemed content to perpetuate or resurrect the ancient crocodilian lore and apply this, with few changes in the acculturation process, to our native *Alligator mississippiensis.*

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3. Antoine François Prevost D'Exiles, *Voyages du Capitaine Robert Lade,* II, pp. 90–100. Paris (1774).
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One of the best examples that I can give, showing how fundamental research can be made to pay, is that of Dr. Langmuir's work in the two fields of thermionic emission and gaseous heat conduction. From one, we have our whole family of high-vacuum tubes, and from the other, the gas-filled incandescent lamp.

The idea of applied research seems to have been adequately sold, but, speaking for the country as a whole, far too little effort is going into basic research. Most of our colleges are pinched for money and will today certainly find it easier to sell the services of their staffs for work in applied science, directed to some specific end, rather than for work in basic research, which may or may not lead to useful applications. Not only this, but even the field in which its applications might lead is unpredictable.

Everybody can see tangible results, but they can easily forget the basic research that established the new facts or principles and made these results possible. It is most desirable that our educational institutions, our scientific societies, our industrial organizations, our labor organizatons, and our government encourage and support basic scientific research. With sufficient basic and applied research, we can confidently hope to maintain and even raise our present high standard of living.

Looking still further into the future, may not a continuous supply of new frontiers, provided by basic research, prevent the stagnation that might otherwise develop in our Western civilization? It is very impressive, and almost frightening, to see some of the remaining evidence of the wonderful achievements of the Mayan civilization in Central America and the Egyptian in Africa, and then to read of the rise and fall of other civilizations, and finally to note the shortness of the time involved in each case. It is clear that there have been various causes contributing to the decline of different civilizations. It seems equally clear that a constant supply of new horizons would not of itself guarantee the continued existence of a civilization. It might well prolong it, however, and would certainly add zest to living.—William D. Coolidge, "A plea for more fundamental research effort," *Science* **119,** 111 (Jan. 22, 1954.)

The Algebra of States and Events

EDMUND C. BERKELEY

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The Algebra of Classes, or Boolean Algebra

BY now a good many people have heard of the algebra of classes, also called Boolean algebra. This algebra has for its main operators AND (·), OR (∨), NOT (′), in the same way as elementary algebra has for its main operators PLUS (+), MINUS (−), TIMES (·), and DIVIDED BY (/). Elementary algebra operates with numbers and with letters that stand for numbers; but Boolean algebra operates with classes or with statements and with letters that stand for classes or statements. The name comes from George Boole, a great English mathematician. (1815–64).

Boolean algebra has important applications in the outlining of rules and contracts, and the designing of on-off circuits for switching and computing; it is being studied and uesd widely in laboratories throughout the country. Boolean algebra is interesting and not difficult, and since it contains no numbers as coefficients as in $3m$ or as exponents as in b^4, it is essentially simpler than ordinary elementary algebra.

Examples of Boolean Algebra

An example of the use of Boolean alegbra for handling conditions is shown in the folowing problem (due to another Englishman, John Venn, about 1894).

Problem 1. A certain club has the following rules: (1) The financial committee shall be chosen from among the general committee. (2) No one shall be a member of both the general and library committees unless he is also on the financial committee. (3) No member of the library committee shall be on the financial committee. Simplify these rules.

Answer: The rules may be simplified as follows: (1) The financial committee shall be chosen from among the general committee. (2) No member of the general committee shall be on the library committee.

Another example of the use of Boolean algebra for dealing with circuit elements is shown in the following problem.

Problem 2. The relay D is energized if and only if all the switches A, B, and C are closed. The relay E is energized if and only if D is not energized and any one or more of the switches A, B, and C are closed. (See Fig. 1). Simplify the circuit for E.

For the benefit of those readers who may not be familiar with relay circuits, an electrical relay is essentially a device consisting of a coil of wire wound around a soft iron core having the property that a contact is switched or transferred when the core is magnetized by running current through the coil. In Fig. 2 the physical structure of a relay is shown: when current flows from

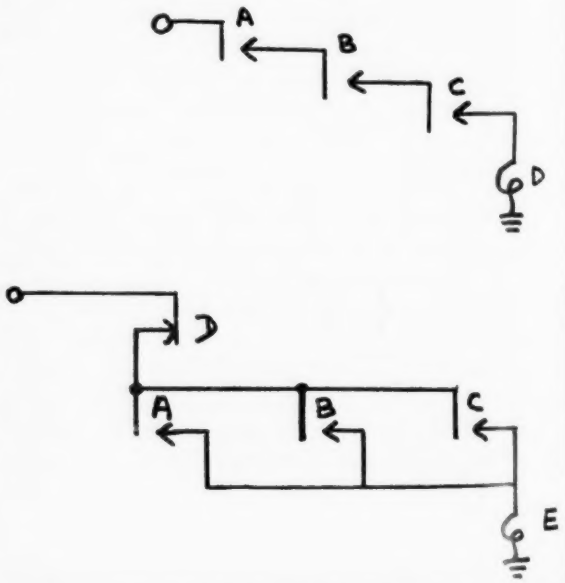


FIG. 1. Circuits to be simplified: the Boolean equations are (1) $D = A \cdot B \cdot C$; (2) $E = D'(A \vee B \vee C)$.

pickup P to ground, the magnetic force pulls down the iron flap or "armature" above, causing the transfer contact T to move away from the normally closed contact NC over to the normally open contact NO. Relays may have more than one set of contacts, T, NC, NO, all switched at once. In Fig. 3 is shown the simpler schematic for a relay and its contacts used in drawing circuits involving a number of relays and contacts.

Answer: The circuit may be simplified as shown in Fig. 4.

Now Boolean algebra is not necessary in order to solve these particular problems, but it is sufficient to solve these problems and many more problems

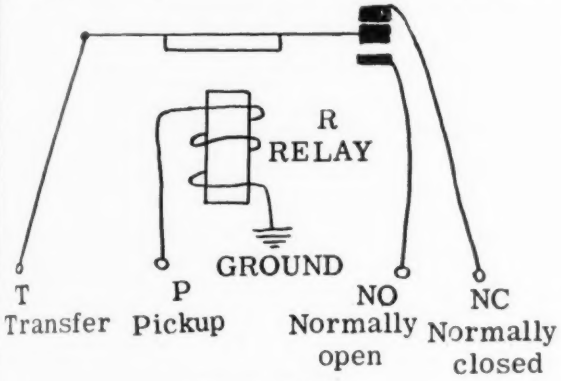


FIG. 2. Relay.

that are more difficult. And it is a straightforward and widely applicable method, more so than most other methods.

It is not our purpose here to explain and state all the rules of Boolean algebra so that it may be understood and calculated with. That information is available elsewhere*.

The Algebra of States and Events

However, there is a large class of problems either in circuits or in contracts involving conditions which change over time. Instead of classes with permanent members, these conditions give rise to classes with membership that fluctuates. Instead of circuits that have only one state, circuits arise that have a succession of states. In these cases Boolean algebra considered as a model for dealing with the situation is deficient, for it contains no variable representing time.

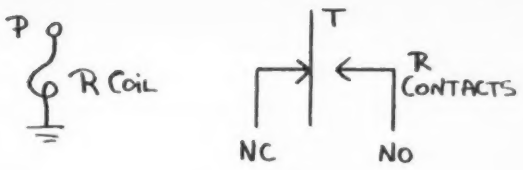


FIG. 3. Relay.

Our purpose here is to present briefly and fairly simply an "algebra of states and events," an algebra which takes into account classes or statements, and a numerical variable representing time, and which is adapted to the study of conditions which change from time to time in some sequence, "sequential conditions." It is equivalent to Boolean algebra extended to include a numerical variable representing time.

Among the concepts contained in this algebra of states and events are BEFORE, AFTER, WHILE, DURING, HAPPEN, CHANGE, BEGIN, FINISH, IN THE EVENT THAT, DELAY, and similar concepts. We can represent these concepts with symbols that we can calculate with, and we can convert concepts symbolically from one form to another form to construct statements and circuits that satisfy sequential conditions.

Binary Variables

A *statement* is an expression which may be true or false. If P stands for a statement, and $T(\ldots)$ stands for the "truth value of . . . ," then we may say that $T(P)$ equals "truth" or "yes" if P is true, and "falsehood" or "no" if P is false. Now these words are not too convenient for compact handling; so let us use 1 for "truth" and 0 for "falsehood." In other words, the *truth value* of a statement P is 1 if P is true and 0 if P is false. If we do not know the truth value of a statement P (capital

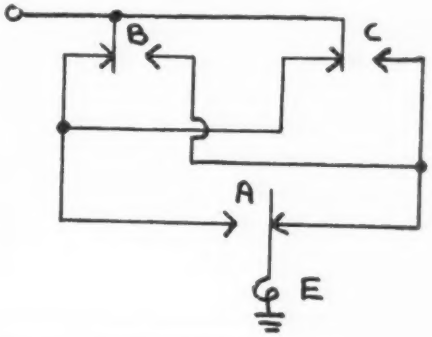


FIG. 4. Simplified circuit: the Boolean equation is $E = A(B' \vee C') \vee A'(B \vee C)$.

* One source is *Circuit Algebra—Introduction*, published by Edmund C. Berkeley and Associates, 36 West 11 St., New York, which also contains a fuller exposition than here given of the algebra of states and events. George Boole's original epoch-making book, *The Laws of Thought*, published in 1854, has been again reprinted, currently by Dover Publications, New York, 1951; but the form of the algebra given in that book has been vastly improved by later mathematicians, especially Ernst Schröder. Another source for Boolean algebra is Chapter XI, "Algebra of Classes," in *Survey of Modern Algebra*, 2nd ed., by Garrett Birkhoff and Saunders MacLane, Macmillan, New York, 1953.

letter), let us use p (lower-case letter) to stand for its unknown or undetermined truth value. Thus p is a binary variable, a variable which can have only 0 or 1 for its values.

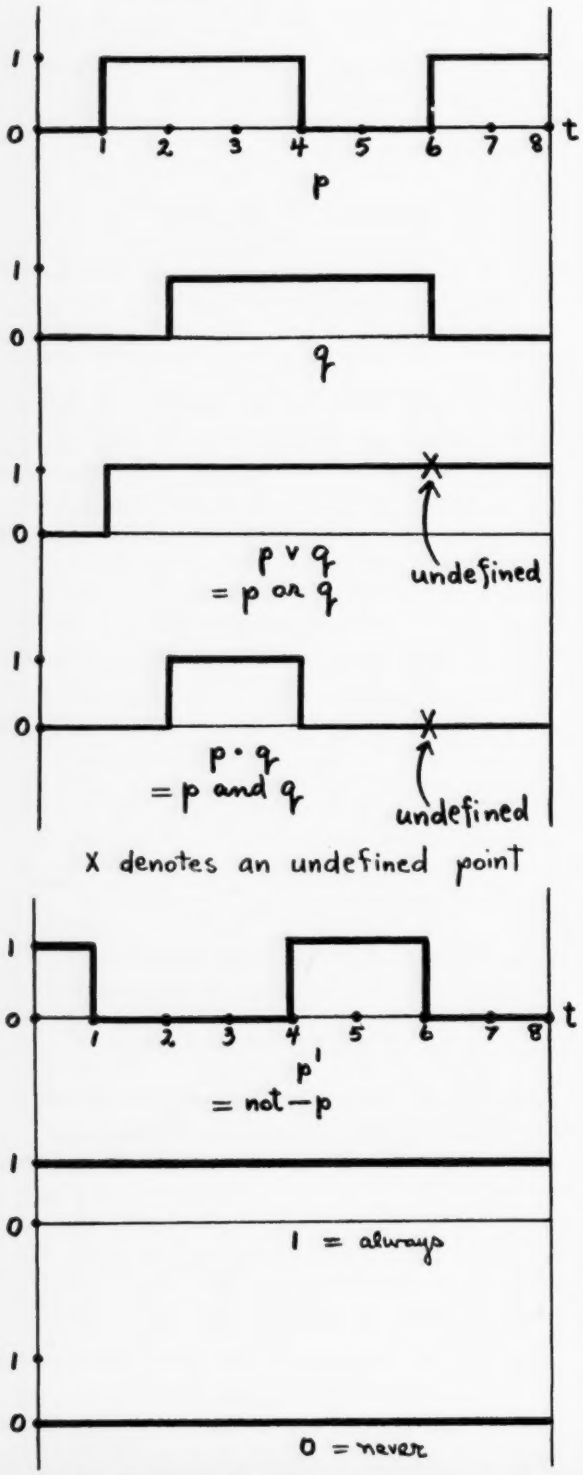


FIG. 5. Binary variables that are functions of time.

From the common meanings of AND, OR (inclusive-OR), and NOT, we can reason out that if P and Q are two statements with truth values p and q, then:

$$\begin{aligned} \mathrm{T}\ (P \text{ AND } Q) &= p \cdot q \\ \mathrm{T}\ (P \text{ OR } Q) &= p + q - pq \\ \mathrm{T}\ (\text{NOT-}P) &= 1 - p \end{aligned}$$

Here the plus sign, multiplication sign, and minus sign are the signs of elementary algebra, and may be used in just that way. It is convenient however to define two new operators. The operator $\vee$ (read "vee" or "or") is defined as: $p \vee q = p + q - pq$. The operator p' (read "not-p" or "p prime") is defined as $1 - p$. It is convenient to read $p \cdot q$ not only p TIMES q but also p AND q.

This much is all Boolean algebra.

Binary Variables Which Are a Function of Time t

Now let us consider a statement which mentions a time t. Such a statement may be "The circuit element E is ON at time t" or "John Q. Smith is alive at time t." The binary variable p which stood for the truth value of a statement P which did not mention time now becomes a binary variable $p(t)$ or p_t or simply p, which is equal to the truth value of a statement P which does mention time.

We now obtain a territory larger than Boolean algebra; we obtain a territory that may be called "the algebra of states and events," or "statal algebra," or "Boolean calculus." This territory is equal to Boolean algebra extended to provide for changes in time.

At any one time p has to be either 0 or 1 or undefined, but over an interval of time the value of p may change from 0 to 1 or from 1 to 0, and if the change is not instantaneous, during the change the value of p is undefined. We consider that we know the binary variable p completely if for each time in the interval we know whether it has the value 1 or the value 0 or is undefined.

The algebra of states and events is of course a natural extension of Boolean algebra, bringing it into closer relation with the real world. For in the real world, the members of a class of objects enter the class or leave the class as time changes. For example, a horse becomes a current member of the class of horses when it is born and ceases to be a current member of the class of horses when it dies. Also, a statement true at one time may not be true at another time. For example, a circuit element on at one time may be off at another time. It is customary in ordinary language to talk about one of these changes of state as an event, and so it is reasonable to speak of this extension of the algebra of classes as the algebra of states and events.

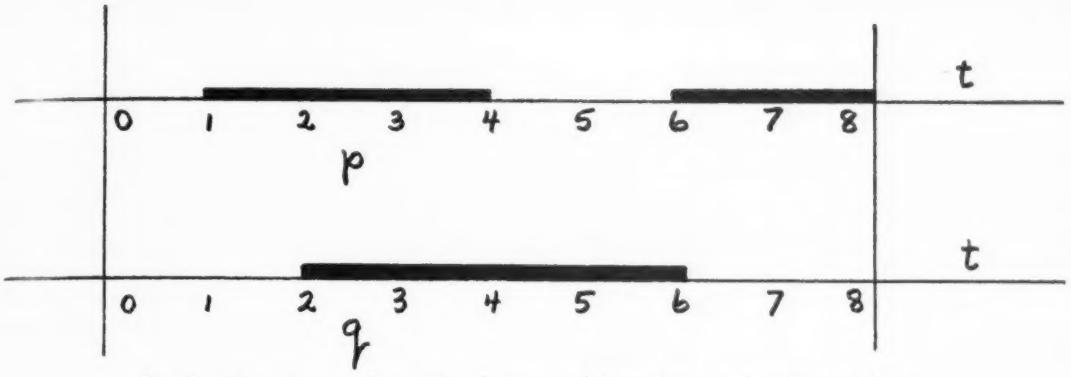


FIG. 6. Second way of graphing binary variables that are functions of time.

Time Units

When we start dealing with p, q, r as functions of time t, the first question we need to consider is: How finely shall we subdivide time? Ordinary differential calculus suggests that we treat time as a "continuous variable," allowing subdivision of time down to infinitely fine subdivisions, much finer than microseconds. This may be theoretically desirable, but it does not correspond very well with at least some aspects of the real world, and we are here primarily interested in the practical handling of conditions and the practical operation of circuits. Practically, it is useful to treat time as consisting of a succession of small finite units of time. For some circuits, seconds are good units, for others milliseconds, and for others microseconds. We shall suppose that we can measure time in units, and we shall often use as a unit either a "little unit," the time that it takes a condition or a circuit element of the type we may be considering to change state from 0 to 1 or from 1 to 0, or a "big unit," which is a large multiple of a little unit, such as 1000 times a little unit.

When we use "little" units of time, p will take all (or most) of a whole unit of time to go from 0 at the start of the unit of time to 1 at the end of the unit of time, and vice versa. When we use "big" units of time, p will ordinarily have just one of the values 0 or 1 for a considerable stretch of time, and every now and then changes will take place as jumps at the beginning or end or some other point in the "big" unit of time. Of course, there will be situations in the real world where neither of these simplifying assumptions works very well, and in such cases we may need to make different assumptions.

Step-Functions

What will our variables p, q, r as functions of t look like when graphed? They will be entirely familiar to us as "step-functions," and will look like the graphs shown in Fig. 5. Here we have provided for 8 "big" units of time along the horizontal axis; we have assumed that it takes the circuit element we are imagining a thousandth of one of these graphed units of time to change from 0 to 1 or from 1 to 0. Also, we have assumed that changes may occur only at the junctions of the intervals.

The first graph shows the function p, which is defined as:

Continuous t	p	Counted t	p
0 to 1	0	1	0
1 to 4	1	2, 3, 4	1
4 to 6	0	5, 6	0
6 to 8	1	7, 8	1

Close to the time t equal to 4 (continuous time t), for example, we shall not know in practice whether p equals 0 or 1; and so here p is undefined. And in practice we contrive the circuit to avoid reliance on such a circuit element at such a time.

The same situation occurs when we go to conditions in real life instead of circuit elements. Suppose p is the truth value of "John Q. Smith is dead at time t." Now there is a day when John Q. Smith dies, and during that day there are moments when he is not yet dead, and moments when he is dead, and a group of moments in between when no one, friend, doctor, or scientist, can actually determine whether he is alive or dead. In those situations, p is in actual fact not defined, and there is little sense in being arbitrary about it and insisting on one definition or another; in actual fact we avoid relying on the information p at a time when it cannot actually be determined whether p is 1 or 0.

In Fig. 5, we have also shown the graph of a function q, which is defined as:

Continuous t	q	Counted t	q
0 to 2	0	1, 2	0
2 to 6	1	3, 4, 5, 6	1
6 to 8	0	7, 8	0

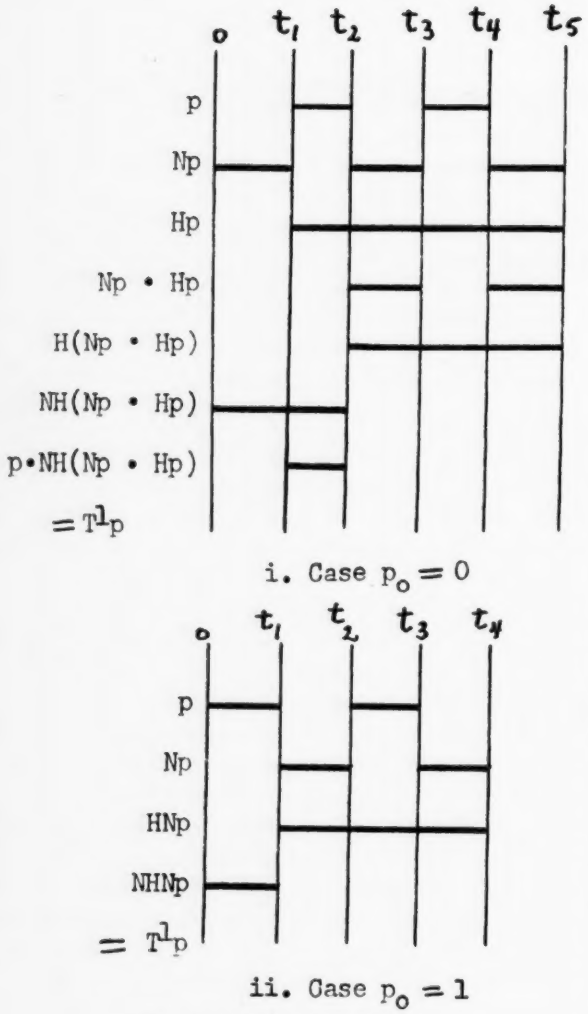


FIG. 7. Calculations of T^1p.

Also, the functions p OR $q = p \vee q$, p AND $q = p \cdot q$, and NOT-$p = p'$, and the functions "always 1" (OR "always") and "always 0" (OR "never"), are also graphed and shown in Fig. 5. Note that $p \vee q$ and $p \cdot q$ have undefined points at $t = 6$.

There is a second way of graphing p, q, r as functions of time, and that is to draw the graph only when it has the value 1. Often this is much more convenient, especially for calculation. See Fig. 6.

In a case where a finite length of time is counted in "little" units, a table of the values of a binary variable p may look like the following:

t	p	t	p
1	0	6	1 to 0
2	0	7	0
3	0 to 1	8	0 to 1
4	1	9	1 to 0
5	1	10	0

This might express the sequential history of a patient with a health record as follows:

t	Statement P	t	Statement P
1	Well	6	Penicillin shot—temperature went to normal
2	Well	7	Normal temperature
3	Fell sick	8	Temperature started up again
4	Fever	9	Another penicillin shot, and down to normal
5	Fever	10	Normal temperature

New Operators

Up to this point, we still have what is almost Boolean algebra; but now we introduce new operators which express such ideas as "before, during, after, happening, starting, finishing, delay, change," etc. See Table 1; it should be examined closely.

The definitions of the new operators given in Table 1 are in many respects obvious. It is easy to express them in terms of each other, and to state theorems. However, in every practical situation the points or intervals where the variables are undefined must be kept in mind and attended to carefully. Following are some comments on a number of the operators.

Delay. The "delay" operator is symbolized D. $D^k(p)$, also written D^kp and p^{+k}, is equal to the binary variable p delayed k units of time, which equals p_{t+k} or $p(t+k)$. In fact, if we think of p as a function f of time t, equal to $f(t)$, then p^{+k} is equal to $f(t+k)$. Note that D^kp is not defined in the interval $t = 0$ to $t = k$, and $D^{-k}p$ is not defined in the interval $t = n - k$ to $t = n$, where n is the last time being considered. An abbreviation for p^{+1} is p' or $\dot{p}$.

Happen. The operator "happen" or "has happened" is symbolized H. $H(p)$, also written Hp, is equal to 1 for every time t after the binary variable p takes on the value 1. More exactly, $H(p_t) = 1$ if and only if there exists a time t_2 such that $t_2 < t$ and $p(t_2) = 1$.

There is an implicit equation relating the delay operator and the happen operator. Let m be a small amount of time (a *moment*), in particular the smallest amount of time sufficient for an on-off circuit element to safely change from 0 to 1 or from 1 to 0. Suppose also that the duration of p is at least as long as m. Then:

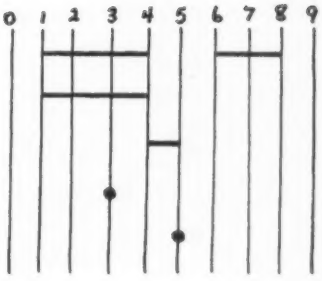
$$H(p) = p \vee D^mH(p)$$

In words, "p has happened if and only if p exists currently, or at a moment ago p has happened, or both."

Symbol	Meaning

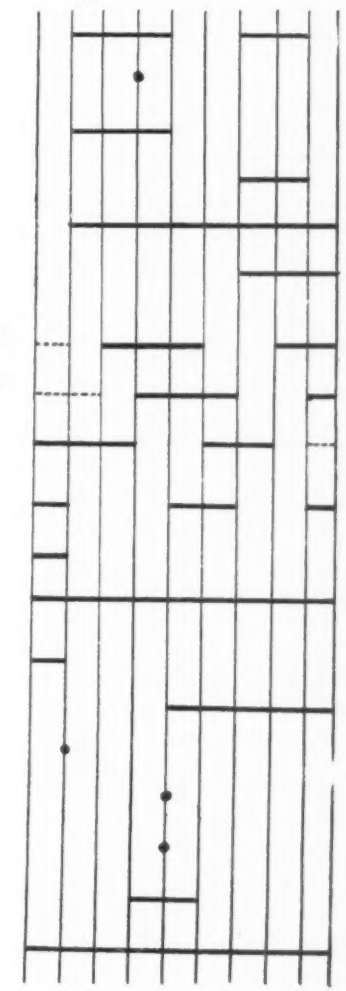
I. Independent variables (functions of time)

p	a state	p
q	another state	q
r	a third state	r
e	an event	e
f	another event	f



II. Dependent variables (functions of the independent variables)

Ip	while p, during p, identically p	Ip
Ie	when e, at e, identically e	Ie
T^1p	p for the 1st *t*ime $(=q)$	T^1p
T^2p	p for the 2nd *t*ime	T^2p
Hp	p has *h*appened	Hp
H^2p	p has *h*appened for the 2nd time	H^2p
D^1p, $p^\cdot$, p^{+1}	p *d*elayed 1 unit of time	D^1p, $p^\cdot$, p^{+1} *
D^2p, p^{+2}	p delayed 2 units of time	D^2p, p^{+2} *
D^{-1}, p^{-1}	p advanced 1 unit of time	D^{-1}, p^{-1}
Np	*not-p*, except when p, except during p, p'	Np
NHp	p has *not* *h*appened	NHp
HNp	*not-p* has *h*appened	HNp
Bq	*b*efore q	Bq
Aq	*a*fter q, q has stopped	Aq
Eq	*e*ntering q, starting q, beginning of q, just in q	Eq
Fq	*f*inishing q, leaving q, end of q, just out of q	Fq
$C(p,r)$	the event state p *c*hanging to state r	C(p,r)
$S(e,f)$	the state from event e to event f	S(e,f)
Zp	$p_0 = 0$; p at time 0 is *z*ero	Zp



* In the dotted intervals, the function is not defined.

TABLE 1. Operators of the algebra of states and events.

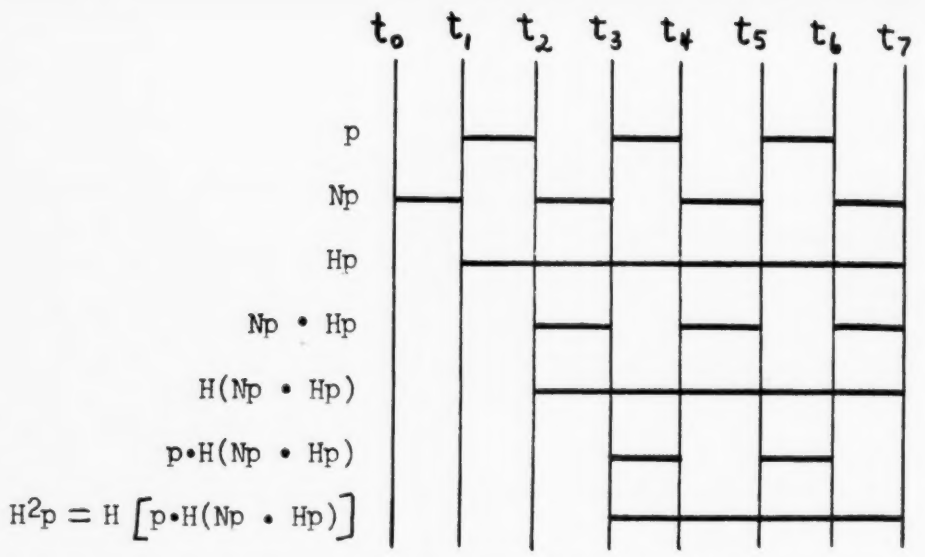


FIG. 8. Calculation of "Has happened for the second time."

Using operators alone, this is:

$$H = I \vee D^m H$$

where I is the "identity" operator, that is, $I(p) = p$.

Not. The "not" operator may be symbolized N. $N(p)$, also written Np, or p', is equal to 0 when p is 1, and 1 when p is 0, and is undefined when p is undefined.

Before. The "before" operator is symbolized B. Let q be a binary variable which has only one *stretch*, that is, only one continuous interval of time during which it has the value 1. Then "before q" is the same as "q has not happened"; in symbols, $Bq = NH\,q$. Using operators alone, $B = NH$.

After. The "after" operator is symbolized A. Then "after q" is the same as "not q, yet q has happened." In symbols, $Aq = Nq \cdot Hq$. Using operators alone, $A = N \cdot H$.

"Before" and "after" can be defined in more than one way for a binary variable with more than one stretch. The definition may take into account such possible meanings as "before the first stretch," "before the last stretch," and "after some stretch." Note that "before any stretch" and "after any stretch" may be ambiguous since "any" may mean "every" or "at least one." The definitions given above for B and A, when applied to a binary variable with more than one stretch, mean "before the first stretch" and "after the first stretch," respectively.

Entering. The "entering" or "starting" operator is symbolized E. Let m be the smallest amount of time sufficient for an on-off circuit element to safely change from 0 to1 or from 1 to 0. It is then a useful definition of "entering" q to say that "entering q" is the same as "q, but a moment ago not-q." In symbols, $Eq = q \cdot ND^m(q)$. Using operators, $E = I \cdot ND^m$.

Leaving. The "leaving" or "finishing" operator is symbolized F. In words, "finishing q" is the same as "not-q, but a moment ago q." In symbols, $Fq = Nq \cdot D^m(q)$. Using operators, $F = N \cdot D^m$.

These definitions make Eq part of q and Fq part of Nq, and resolve some ambiguous cases where q would otherwise be undefined.

We can see that as m gets smaller and smaller without reaching 0, the states Eq and Fq can still have a value 1. But in the limit, when m equals 0, we have in both cases $q \cdot q'$, which by Boolean algebra equals 0, and by elementary algebra $q \cdot q' = q(1-q) = q-q^2$, but $q^2 = q$ for both 1 and 0, and so $q-q^2 = q-q = 0$ identically.

The Event of Changing from One State to Another State. The event of changing from one state p to another state r is $C(p, r) = [Fp \text{ AND } Er] = Fp \cdot Er$.

The State from One Event to Another Event. A state S may be defined as beginning with one event e and stopping with another event f. There are two cases. In the first case we think of the state S from the first occurrence of e to the first occurrence of f. This is simple and is equal to $He \cdot NHf$; that is, e has happened and f has not happened. In the second case, we think of the state S from any occurrence of e to the next following occurrence of f. We express this as $S(e, f)$, or S. Technically, e equals 1 at times $t_1, t_3, t_5 \ldots$ for a finite number of values, and 0 elsewhere; f similarly equals 1 at times $t_2, t_4, t_6 \ldots$ for a finite number of values and 0 elsewhere. Consider any of $t_1, t_3, t_5 \ldots$ and find

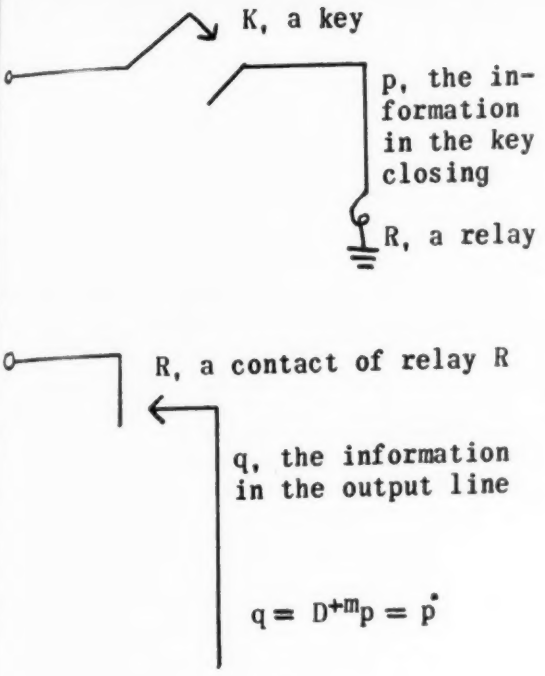


FIG. 9.(a).

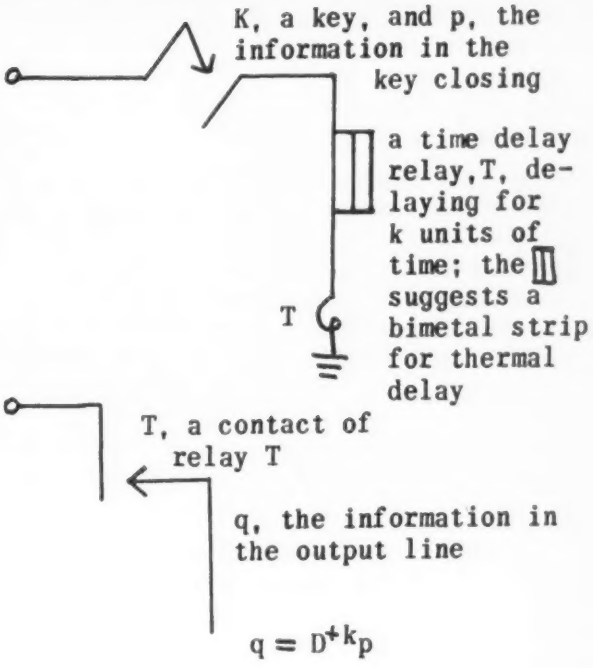

K, a key, and p, the information in the key closing
a time delay relay, T, delaying for k units of time; the suggests a bimetal strip for thermal delay
T
T, a contact of relay T
q, the information in the output line
q = D+kp

FIG. 9(b).

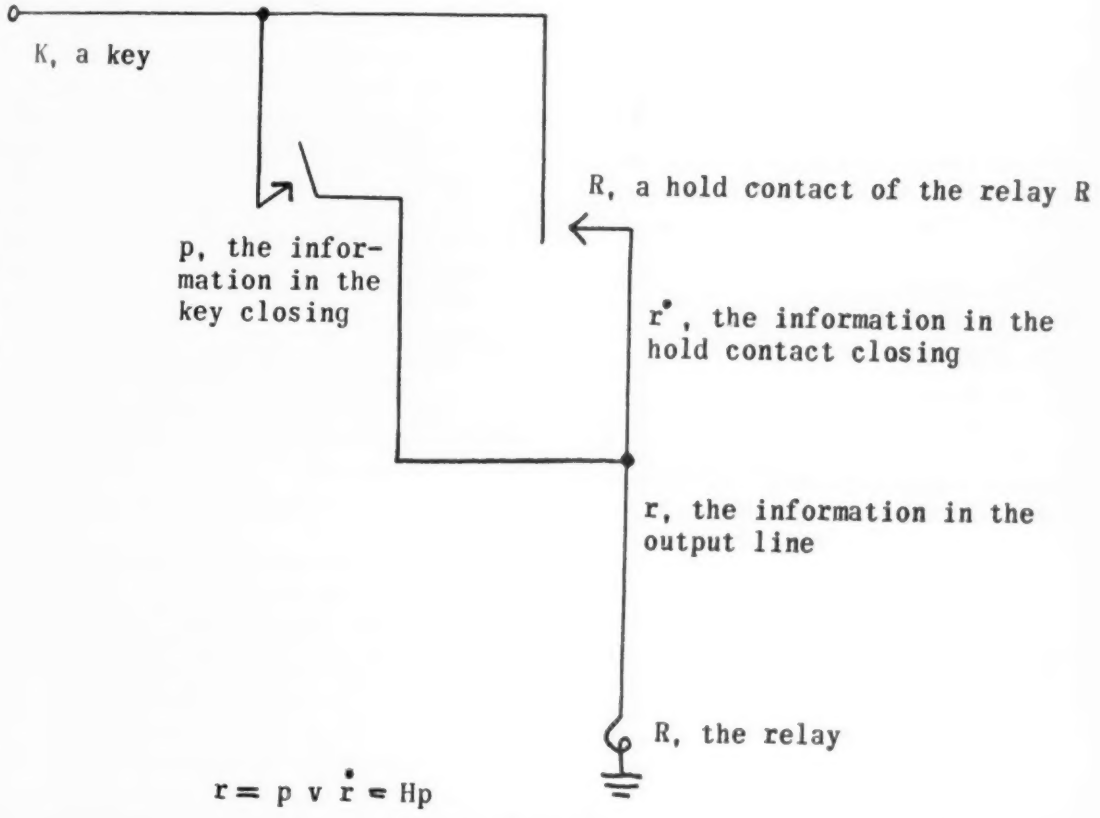

K, a key
R, a hold contact of the relay R
p, the information in the key closing
ṙ, the information in the hold contact closing
r, the information in the output line
R, the relay
r = p v ṙ = Hp

FIG. 9(c).

the value of t_2, t_4, t_6 . . . which next follows. Suppose they are t_i and t_j respectively. Then the state S equals 1 for every t from t_i to t_j, including t_i but not t_j. This function S has the convenient property:

$$S = Nf \cdot [e \vee D^m S]$$

In words, the state S is equal to "the event f is not happening, and either the event e is happening, or a moment ago the state S was happening or both." If e and f are both 1 during the same small period of time, S in this period is undefined. If the duration of e is shorter than m, the smallest amount of time sufficient for a circuit element to safely change state, then it is as if e were 0; and the same is true for f.

For the First or Second Time. The operator "is happening for the first time" is symbolized T^1, and the operator "is happening for the second time" is symbolized T^2. Let p be a binary variable that has more than one stretch. Then we may be interested in distinguishing between the various stretches: T^1p, the first stretch, "p is happening for the first time"; T^2p, the second stretch, "p is happening for the second time"; and so on. For example in Table 1, $q = T^1p$. There are two cases, corresponding with $p_0 = 0$ and $p_0 = 1$. We can calculate T^1p for each case graphically as shown in Fig. 7. We can see that the first case is more general, and includes the second; so we can write:

$$T^1p = I \cdot NH(N \cdot H)\,(p)$$
$$= [Z \cdot I \cdot NH(N \cdot H) \vee NZ \cdot NHN]\,(p)$$

Happened for the Second Time. The operator "has happened for the second time" is symbolized H^2. From the general graphic calculation shown in Fig. 8, we can compute:

$$H^2p = H[I \cdot H(N \cdot H)]\,(p)$$

And we could continue with a large number of the ramifications of the algebra of states and events, but probably enough has been said to show many ways in which it can be further developed.

The main difference between a state and an event is duration. States are long and events are short. But it is a relative difference, not an absolute one; for an event must not be shorter than m, the least time for a circuit element to change state safely, and it is possible for a state to be as short as that. Events, however, are likely to occur without overlapping; that is, their overlapping can ordinarily be neglected. States, on the other hand, are long, and they are likely to occur with overlapping between them, and their overlapping needs to be considered.

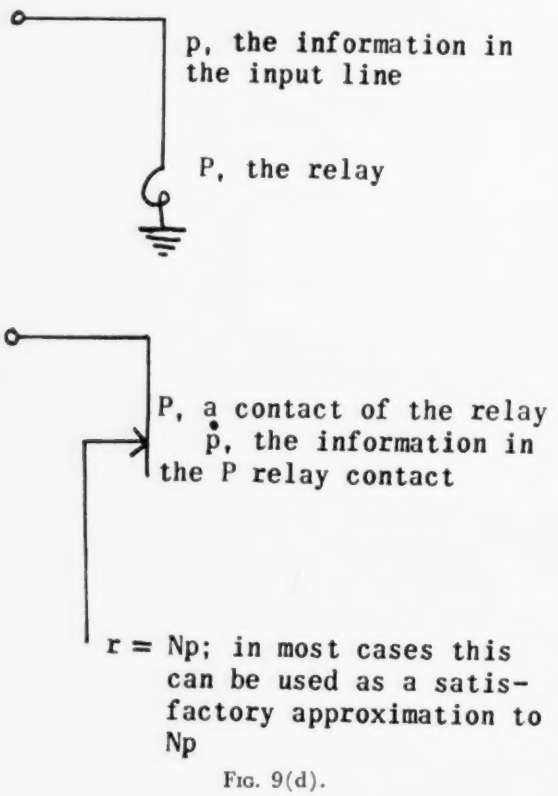

p, the information in the input line
P, the relay
P, a contact of the relay
p, the information in the P relay contact
r = Np; in most cases this can be used as a satisfactory approximation to Np

FIG. 9(d).

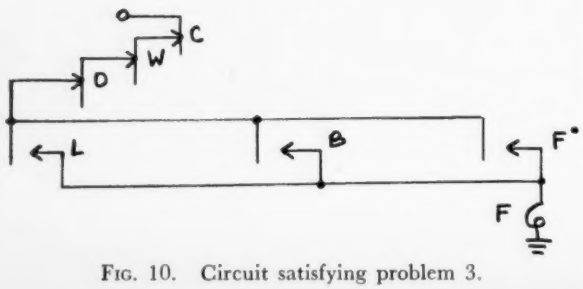


FIG. 10. Circuit satisfying problem 3.

Applications of the Algebra of States and Events to On-off Circuit Elements

With the algebra of states and events, we can be both more accurate and more complete in our analysis of the operations of on-off circuit elements. However, we shall consider only one kind of circuit element, relays.

A relay becomes energized and its contacts operate AFTER it is energized by current, instead of—as ordinarily assumed when using Boolean algebra—at the same time. A small amount of time, the "operate-time" of the relay, is needed for a magnetic field to build up in the coil of the relay and to cause its contacts to close. The operate-time of any relay ranges from about 3 milliseconds for a very fast relay, to 20 to 40 milliseconds for ordinary relays, up to a half second or longer for slow-acting relays or time-delay relays.

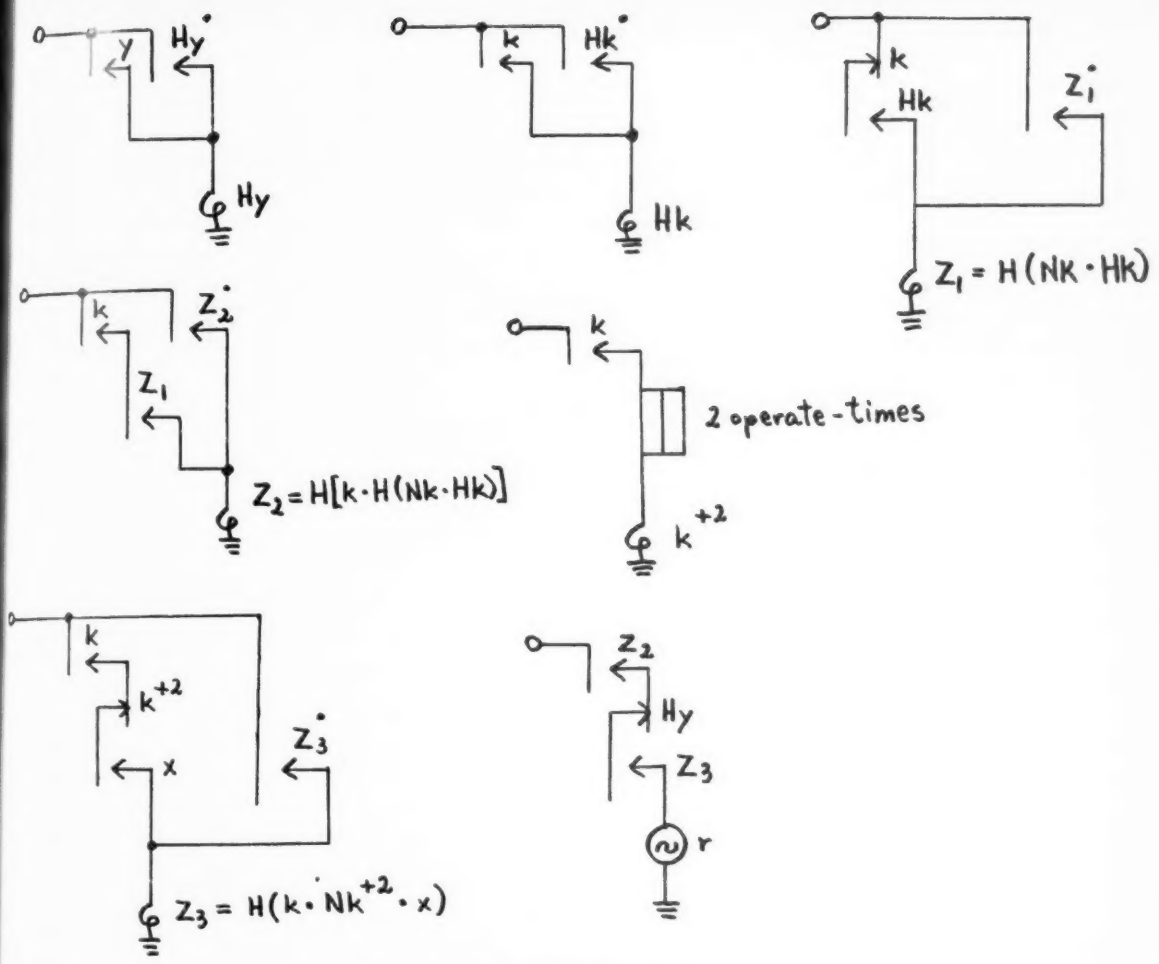


FIG. 11. Circuits satisfying problem 4.

The four chief functions of the new algebra that we desire to represent in the operation of relays are $D^{=m}p$, $D^{\geq k}p$, Hp and Np. Here m is the safe operate-time of a relay; k is any longer period of time; and the duration of p is not less than m. We show in Fig. 9 circuits which represent these four chief statal algebra functions in relays.

Some Problems and Solutions

Now the chief test of this algebra of states and events is not so much whether it is as yet mathematically entirely rigorous but whether it applies helpfully in solving problems. For mathematical rigor can came more than fifty years later, as it did with ordinary calculus and also with Boole's sketch of his algebra in 1854.

Here then are some samples of problems that this algebra can apply to.

Problem 3. An automatic oil furnace (F) is to run whenever the living room thermostat (L) calls for heat, or when the associated hot water boiler thermostat (B) calls for more hot water. It is to stop whenever the temperature in the chimney (C) is too high, or the water level in the boiler (W) is too low, or when the oil level in the fuel tank (O) is too low. Express F in a relay.

Solution: Let the binary variables of the conditions be as marked by the letters above in the problem. Then, using the formula for the state from one event to another, the statal algebra equation for the circuit is:

$$F = C' \cdot W' \cdot O' \cdot (L \vee B \vee F^{+1})$$

The circuit is shown in Fig. 10.

This problem is typical of the kinds of problems that arise in programming a complex piece of apparatus in order that it may carry out a number of different modes of behavior.

Problem 4. Design a set of relay circuits with a key k and depending on two conditions x and y such that lamp r will light if the key has been pressed

twice, y has never occurred, and x was or is on at a time when the key was or is pressed.

Solution:

$$r = \mathrm{H}^2(k) \cdot \mathrm{B}(y) \cdot \mathrm{H}(\mathrm{E}k \cdot x)$$

Now

$$\mathrm{H}^2(p) = \mathrm{H}[p \cdot \mathrm{H}(\mathrm{N}p \cdot \mathrm{H}p)], \ \mathrm{B}(p) = \mathrm{NH}p, \ \mathrm{E}p = p \cdot \mathrm{N}p^{+1}$$

therefore

$$r = \mathrm{H}[k \cdot \mathrm{H}(\mathrm{N}k \cdot \mathrm{H}k)] \cdot \mathrm{NH}y \cdot \mathrm{H}(k \cdot \mathrm{N}k \cdot x)$$

We need to discuss $\mathrm{E}k = k \cdot \mathrm{N}k^{+1}$. We desire to pick up a relay while this condition exists. This condition by definition will only last for about the time that a relay can pick up. Hence the operation of the circuit will be uncertain. So let us assume a slower relay for which k^{+2} will apply instead of $k^{+1} = k$. We will then substitute $\mathrm{E}k = k \cdot \mathrm{N}k^{+2}$. The circuits are shown in Fig. 11.

Much more could be said about this algebra of states and events and its application to other sorts of conditions and on-off circuit elements. But probably enough has been said to show to some extent its usefulness, its power, and its applications.

The discovery of transcendentals, the establishment of the fact that they are far richer in extent and variety than the irrationals of algebra, that they comprise some of the most fundamental magnitudes of modern mathematics—all this showed definitely that the powerful machinery of algebra had failed just where the elementary tools of rational arithmetic had failed two thousand years earlier. Both failures were due to the same source: algebra, like rational arithmetic, dealt with *finite processes* only.

Now as then, infinity was the rock which wrecked the hope to establish number on a firmer foundation. But to legalize infinite processes, to admit these weird irrational creatures on terms of equality with rational numbers, was just as abhorrent to the rigorists of the nineteenth century as it had been to those of classical Greece.

Loud among these rose the voice of Leopold Kronecker, the father of modern *intuitionism*. He rightly traced the trouble to the introduction of irrationals and proposed that they be banished from mathematics. Proclaiming the absolute nature of the integers, he maintained that the natural domain, and the rational domain immediately reducible to it, were the only solid foundation on which mathematics could rest.

"God made the integer, the rest is the work of man," is the famous phrase by which he will be best known to posterity. This phrase reminds me of the story of the pious old dame who was heading a committee for the erection of a new church. The architect who submitted the plans found that the old lady took the business very seriously. Most vehement was her protest against the stained glass for which his specifications called. Finally in despair he asked her on what ground she objected to stained glass. "I want my glass the way the Lord made it!" was her emphatic reply.—Tobias Dantzig, *Number: The Language of Science* (Macmillan, New York, ed. 4, 1954), p. 118.

Factors Affecting Vertical Temperature Gradients in the Upper Layers of the Sea*

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THE temperature of the sea is not uniform, but varies in space as well as time. The resulting changes of temperature with depth are known as vertical temperature gradients. Major gradients are most common in the upper layers where external environmental influences predominate. Temperature gradients in the sea are important in explaining many physical, chemical, and other ecological phenomena.

Since the advent of the bathythermograph about a decade ago, a great deal of information concerning the detailed structure of the surface layers of the Pacific Ocean has been compiled. However, few comprehensive studies of the thermal structure have been made, owing in part to the complexity of the problems involved. This report, based largely on the results of empirical studies, points out in a simplified version many factors which contribute to the production, or elimination, of vertical temperature gradients in the sea.

The numerous factors may be divided into two groups: energy transfer processes at the sea surface and advective transfer processes below the sea surface. Those factors concerned with the transfer of solar radiation to the sea result, by selective absorption, in highest temperature nearest the surface, thus producing "negative" temperature gradients. Conversely, the removal of heat from the sea tends to eliminate negative gradients and to produce slightly "positive" gradients, with higher temperatures below the surface.

The second group of factors producing temperature gradients in the sea is concerned with the external and internal forces which cause movement and displacement in the water without a transfer of heat to or from the atmosphere. These forces produce tide, current, wind, and so forth, which transport water from one place to another. If the advected water differs in temperature from the adjacent water in its new environment, a temperature gradient, vertical or horizontal, will be produced. Certain geographical and density boundaries will influence the path of the transported water, and thus influence the gradients.

Each single factor affecting temperature gradients in the sea is here considered independently. However, in nature several invariably operate simultaneously, and in many cases are dependent upon one another. No attempt is made to evaluate the relative frequency of occurrence or importance of each factor.

The bathythermograms consist of temperature-depth curves superimposed on a grid. The vertical scale extends from the surface to about 500 feet, and the horizontal scale from 30° to 90° F. For the purpose of illustration, the bathythermograms are combined with the imaginary block of sea water or environment, both of which have the same vertical scale. The horizontal scale, however, should be interpreted only as direction (Fig. 1). The temperature scales are comparable for all curves except where more than one curve appears in a figure. In these cases the shapes of the curves are relative to

* Work completed while professor of oceanography at Andhra University, Waltair, India, 1952–53.

† The author is indebted to those who contributed helpful suggestions and aided in preparing the figures, and to the Andhra University for providing facilities and assistance in completing this paper.

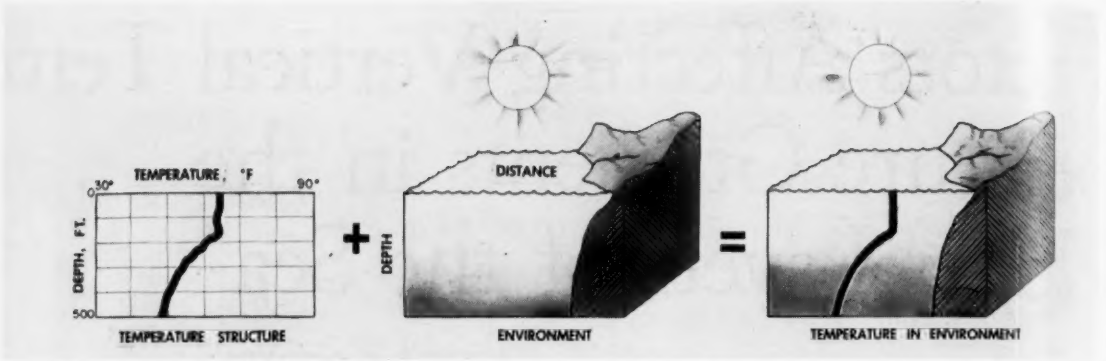


FIG. 1. Method of illustrating temperature structure in specific environment.

each other but are not necessarily comparable with other temperature scales.

Minor irregularities which usually occur *in situ* are eliminated and a smoothed representation is shown.

Temperature Gradients Resulting from Energy Transfer at Sea Surface

The most common factor in the production of thermal gradients near the surface is simply the transfer of heat at the sea surface. The main processes of heating the sea surface are the absorption of radiation from sun and sky, Q_s; convection of sensible heat from the atmosphere, $-Q_h$; and condensation of water vapor, $-Q_e$. These processes produce negative gradients near the surface. On the other hand, cooling, or reverse processes, have the opposite sign. Back radiation from sea surface, Q_b, convection of sensible heat to the atmosphere, and evaporation, reduce negative gradients and sometimes produce slightly positive gradients near the sea surface.

A combination of these factors gives:

$$Q_s - Q_b - Q_e - Q_h = Q_T$$

where Q_T is the heat transferred to the water at the surface to produce temperature gradients.

Radiation. The radiation available to heat the sea surface (total radiation minus back radiation) depends upon the altitude of the sun, absorption in the atmosphere, and cloudiness. Under conditions of high radiation, that is, during sunlight hours or in summer, heat is transferred over a period of time from the atmosphere to the water. This heat added to the water is absorbed mainly at the surface, and consequently develops negative temperature gradients. The magnitude and depth of gradients are proportional to the amount of heat added, mixing, and so forth (Fig. 2).

When the solar radiation reaching the sea surface is low, that is, at night or in the winter, negative gradients are so reduced that slight positive gradients are frequently formed. At these times heat has been transferred from the water to the atmosphere.

Radiation may be modified by the amount and types of clouds. Heavy cloudiness in the sky reduces the amount of solar radiation reaching the sea, and consequently interferes with the development of temperature gradients. When a light cloud coverage is present, relatively more heat is transmitted and results in stronger negative gradients. Of course, the largest surface gradients are produced by this effect when the sky is clear.

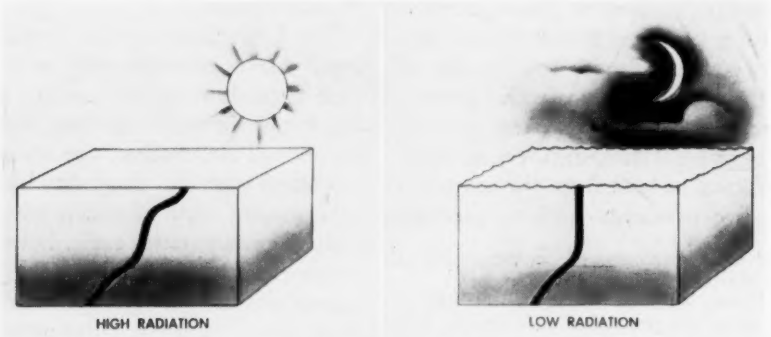


FIG. 2. Radiation

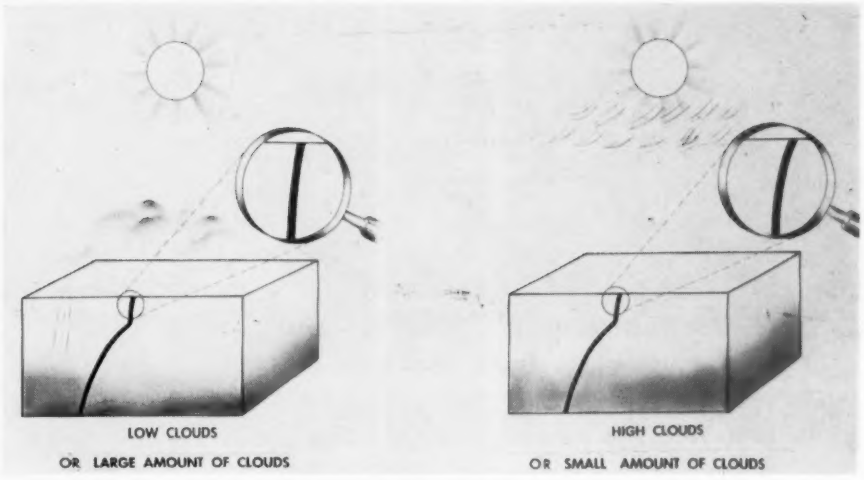


FIG. 3. Radiation modifier: clouds.

The cloud factor in the formation of temperature gradients is mainly confined to the surface layer. However, when long periods of clear or cloudy weather persist, the effect will extend, by absorption and diffusion, to deeper layers. Clouds not only prevent solar radiation from reaching the sea, but they also act as a blanket, or "greenhouse" effect at night, to reduce cooling of the sea surface.

Cloud types vary in density and thus in the amount of heat they reflect and transmit. Low clouds, such as stratocumulus, are denser and prevent the production of surface temperature gradients more than do the same amount of high cirrus clouds (Fig. 3).

Convection. The convection of sensible heat to and from the sea surface depends largely upon temperature difference, sea surface temperature minus air temperature. This temperature difference between the sea and the air produces temperature gradients by convection. When the sea is warmer than the air, weak positive gradients are formed near the sea surface. These temperature increases with depth are usually 0.1° to 0.3° F. When the air is warmer than the sea surface, negative temperature gradients develop at the surface. The magnitude of gradients produced by convection over a period of time is proportional to the temperature difference between sea and air, other variables being constant. However, the total heat transferred to the sea is generally small, due to low specific heat of the air and the stability of both air and sea which develops under these conditions (Fig. 4).

Evaporation. Evaporation or the reverse, condensation, depends on the vapor pressure difference, that is, vapor pressure at the sea surface minus vapor pressure of the air. When the vapor pressure at the sea surface is greater than the vapor pressure of the air above, heat will be removed from the sea to the atmosphere by the process of evaporation, and will result in a slight positive gradient near the surface. Conversely, if the vapor pressure above the surface is greater than at the sea surface, heat will

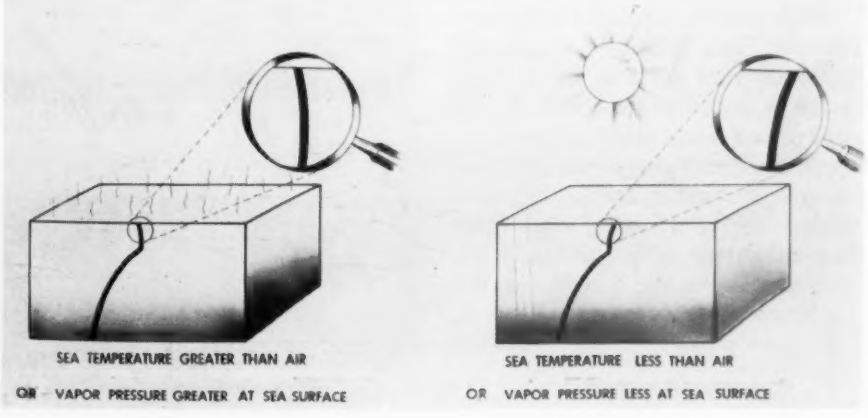

SEA TEMPERATURE GREATER THAN AIR
OR VAPOR PRESSURE GREATER AT SEA SURFACE
SEA TEMPERATURE LESS THAN AIR
OR VAPOR PRESSURE LESS AT SEA SURFACE

FIG. 4. Convection, evaporation, and condensation.

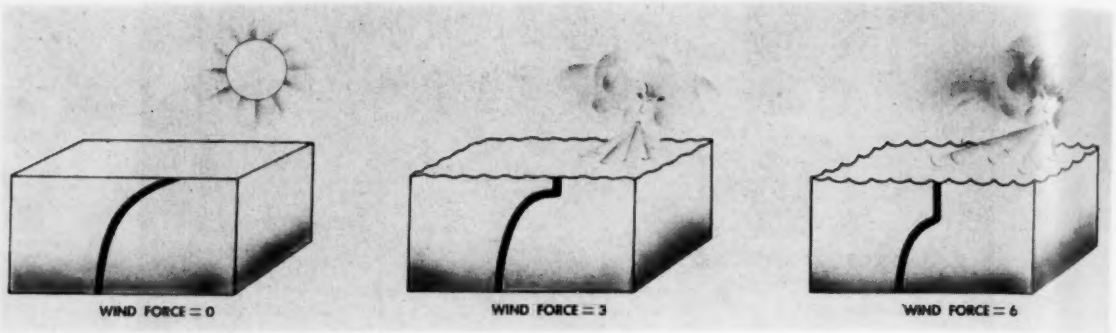


FIG. 5. Wind force.

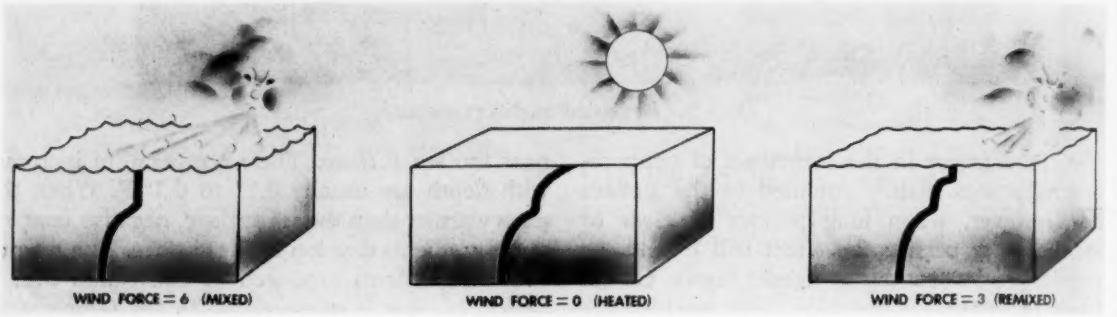


FIG. 6. Wind force variations.

be added to the water by condensation. This results in negative temperature gradients at the surface (Fig. 4). Note that it is possible for convection and evaporation to be acting in opposition to each other.

Temperature Gradients Resulting from Advective Processes below Sea Surface

When variation in currents causes lateral or vertical displacement in the sea, the resulting water masses are redistributed and temperature gradients are affected. These water movements or advective factors may be further broken down into wind characteristics, current types, boundary influences, and so forth.

Wind Force. Surface temperature gradients vary inversely with the wind force. When the wind force is "0" Beaufort, heating may occur at the surface, thus resulting in large negative gradients. As the wind force increases, the surface layers will become mechanically mixed, thus producing a homogeneous layer, which is devoid of temperature gradients to the depth of mixing. With increasing wind force the mixing will extend deeper (Fig. 5). The depth of mixing will also depend on the duration of the wind, its fetch, and upon the density gradients in the water. With a wind force of "4" to "5" Beaufort (12 to 21 miles per hour), the mixing usually extends to at least 30 feet.

Wind Force Variations. When a wind-mixed water column is heated at the surface and is again remixed by a weaker wind, steps will be formed in the temperature depth curve. These successive mixings and heatings are common in the spring and result in a series of negative gradients and isothermal layers. When the wind-produced discontinuities are first formed they are sharp (Fig. 6).

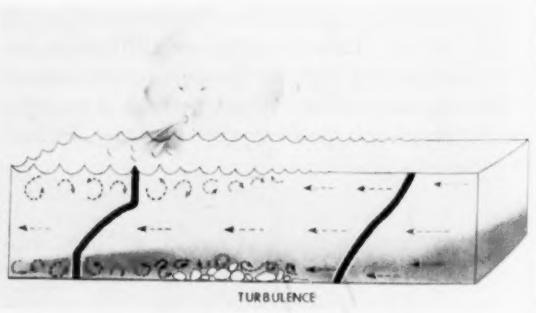
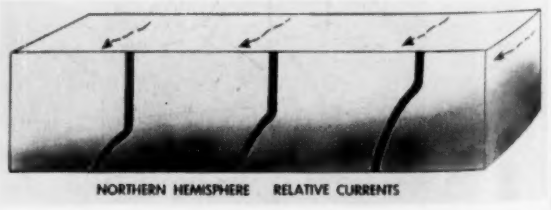


FIG. 7.



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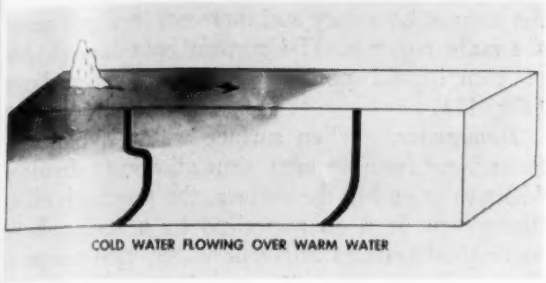

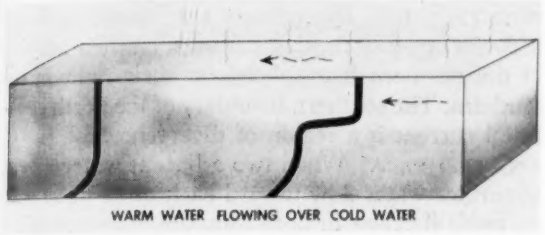

FIG. 9. Horizontal displacement currents.

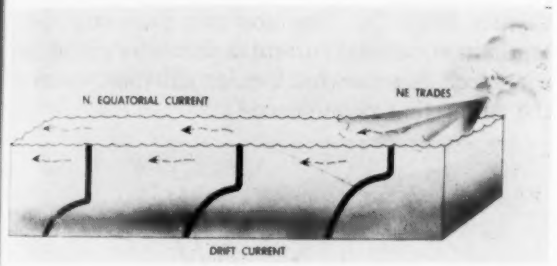

FIG. 10.

Over a period of time diffusion reduces the sharpness of these gradients, and the seasonal thermocline thus developed appears as a continuous gradient.

Turbulence. Temperature gradients may be influenced by surface and subsurface turbulent mixing of the water column. At the surface, as previously mentioned, wind and waves produce an isothermal layer. However, below the surface, mixing can also take place where currents flow over rough sea bottom (Fig. 7). The magnitude of the turbulent layer depends upon speed of current and roughness of bottom.

Relative Currents. Currents relative to some depth where motion is assumed to be negligible are controlled by the horizontal change in average vertical density of the water and Coriolis force. In the northern hemisphere the water on the right-hand side of the current is lighter, and consequently usually has a deeper surface layer than the water on the left-hand side of the current (Fig. 8). In the southern hemisphere the lighter water is on the left-hand side of relative currents. These are characteristic of the California and Humbolt currents respectively.

Displacement Currents. In regions where one type of water flows over and displaces another type, gradients will be formed at the boundary between the two waters. Where cold water of low salinity overrides warmer water of higher density, a positive temperature gradient will occur at the boundary. The converse occurs when warm water flows over and displaces colder water (Fig. 9). These types of displacement are common along the southern boundary of the cold Oyashio Current off the Kuril Islands and the eastern terminus of the Equatorial Counter Current off Central America. Gradients thus produced are usually sharp.

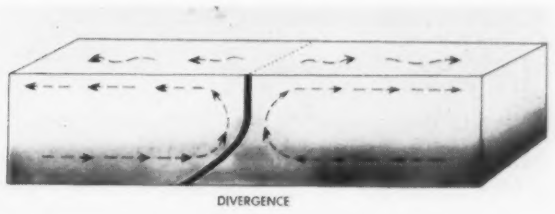

FIG. 12.

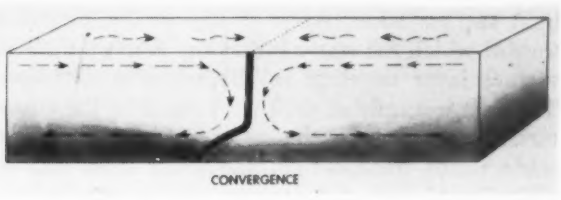

FIG. 13.

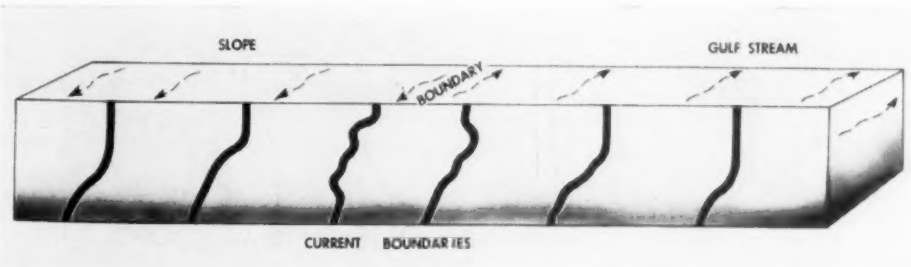

FIG. 11.

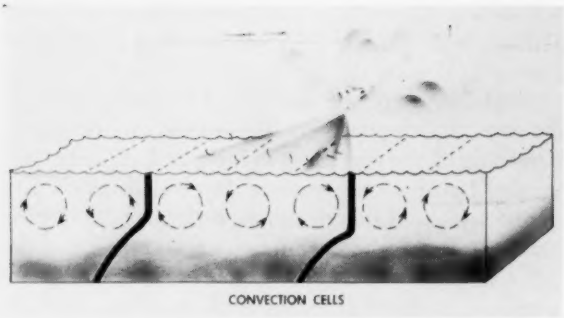

FIG. 14.

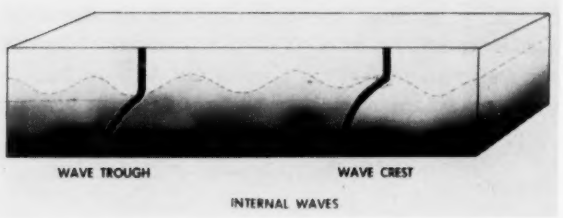

FIG. 15.

Drift Currents. When the wind blows over the surface of the sea for long periods, surface water, in the northern hemisphere, drifts slightly to the right of the direction in which the wind is blowing. This results in the piling up of a deeper layer of light surface water more or less in the direction toward which the water is moving. A more shallow surface layer develops in the opposite direction. The best example of drift currents is in the equatorial region where the northeast and southeast trade winds transport surface water from east to west. In this region the transported water forms a progressively deeper surface layer in the direction of the current (Fig. 10).

Current Boundaries. When adjacent currents of different temperature characteristics flow in opposite directions or at different speeds, the boundary between the currents will be made up of numerous eddies. In the boundary layer many irregular and complex gradients will be produced. A good example is the boundary of the Gulf Stream and Slope Current. Here the surface layer is shallow at the current boundary and increases in depth across the main currents. The current boundary consists of complicated positive and negative gradients (Fig. 11).

Divergence. When surface water is blown or flows away from an area, thus allowing subsurface water to ascend to the surface, the process is called divergence. It is characterized by a surface layer more shallow than adjacent water, and temperature gradients are usually weaker in the thermocline (Fig. 12). Divergences are frequently found between opposite flowing currents, on their left side in the northern hemisphere, on their right in the southern. The southern boundary of the north equatorial current is a region of divergence.[1]

Convergence. When two adjacent water masses of surface water flow toward each other or at such an angle that one or both sink, the process is called convergence. In regions of convergence the surface layer will be deeper and the thermocline usually sharper (Fig. 13). The northern boundary of the southern equatorial current is characteristic of convergence.[1] A somewhat similar situation occurs at the Antarctic Convergence.[2]

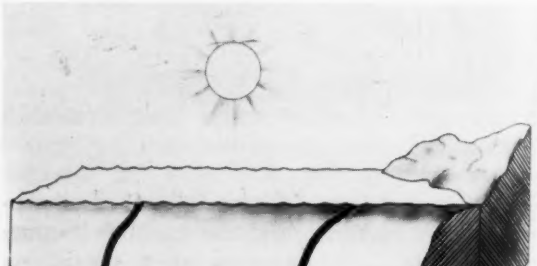

FIG. 17. Land boundaries.

Convection Cells. Convection cells are believed to be a series of convergences and divergences of water on a smaller scale. These cells are occasionally produced by strong winds during a period of surface cooling. The axis of the cell will be parallel to the direction of the wind. The diameters of the cells

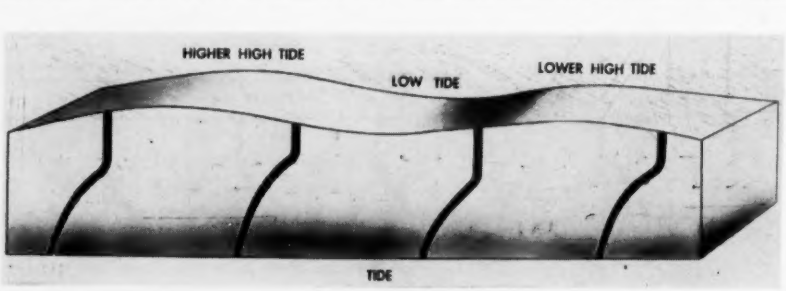

FIG. 16.

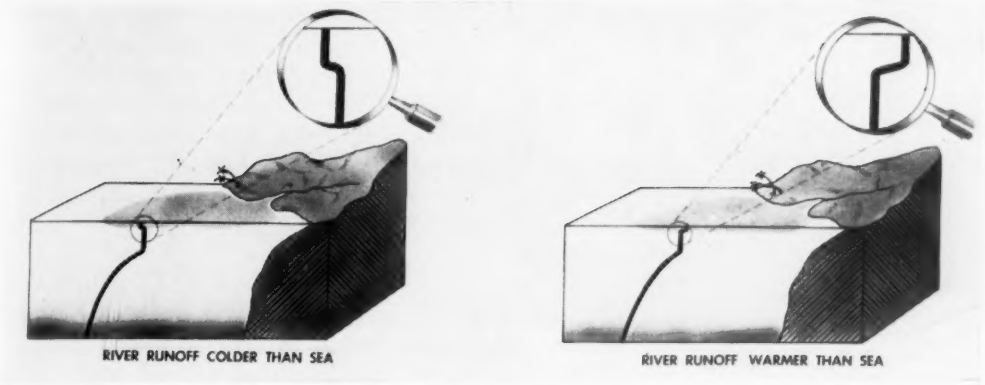

FIG. 18. River runoff or surface dilution.

are approximately equal to the depth of the mixed layer, but the depth of the mixed layer may vary on either side of the cell. The thermocline will be deeper when the circulation is downward, more shallow where it is upward (Fig. 14). Regions of convergence are characterized by surface slicks.[3, 4] A similar long interlocking series of pronounced cellular circulations is found in the Bay of Bengal. There, also, the thermal structure below lines of convergence gives deeper surface layers with sharper gradients than does the structure beneath lines of divergence.

Internal Waves. Internal waves occur at the boundary between density layers. These waves are universal and vary widely as to height and period. Their amplitude may be as great as several hundred feet, and their period from a few seconds to many hours, or longer. The change in layer depth caused by an internal wave results in a deeper surface layer over the trough than over the crest (Fig. 15).[3, 5]

Tide. Layer depth is influenced by the tide. In general, a semilunar "internal tide," has been observed. The phase of the internal tide varies with both time and location. In the majority of cases a shallow surface layer, or internal high tide, occurs three to five hours after high tide at the surface, and a deeper surface layer or internal low tide occurs three to five hours after low tide at the surface (Fig. 16).[5]

Land Boundaries. The proximity to shore influences the vertical temperature structure. This is believed to be due to the presence of weaker winds and to the greater absorption of heat near shore. The waters near shore are more turbid, contain more microorganisms, and consequently absorb more radiation. This results in stronger negative gradients in summer. The phenomenon is more pronounced in lower latitudes and where discharges enter the sea. The reduced winds as well as greater thermal gradients near shore are believed to result in less mixing in winter. Consequently, the layer depth near shore is usually less than the layer depth farther out at this time (Fig. 17).

River Runoff or Surface Dilution. The fresh water discharged into the sea from rivers is almost always lighter than the sea water and it flows on top. If the river water is colder than the sea, a positive gradient will result at the boundary; if warmer, a negative gradient is produced (Fig. 18). The depth of the gradient and the area of the sea covered are dependent upon the size of river discharge, amount of mixing in the connecting estuary, and alongshore currents. For example, off the Ganges River in the fall season a 20 percent dilution of sea surface may extend seaward for at least 500 miles and to a depth of over 150 feet. The diluted surface water may be subjected to heating and cooling that cause negative and positive gradients in the surface layer and still retain a vertical stability.

Upwelling. When the surface water is carried away from shore by wind drift, deeper water rises to take its place. This type of vertical motion of subsurface water toward the surface is known as upwelling (Fig. 19). The phenomenon is similar to

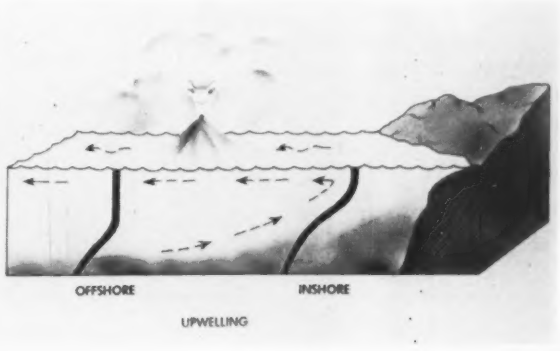

FIG. 19.

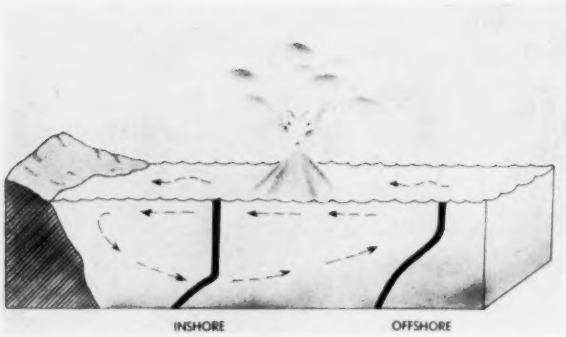

FIG. 20. Sinking.

divergence. However, upwelling usually takes place near a land boundary, and the upwelling water flows in one direction when it reaches the surface. In regions of upwelling, such as off the coast of Southern California, the thermocline will be nearer the surface. Because the upwelled water comes from lower depths, it will almost always be colder, with gradients weaker than in adjacent regions where no upwelling occurs.

Sinking. The opposite of upwelling is called sinking. This phenomenon occurs when the wind blows in such a direction as to cause the surface water to be transported toward a coast. In this case the deeper surface layer is built up nearer the coast and immediately off shore (Fig. 20).[6] A sinking region is characterized by deep and usually sharp thermoclines. Such a temperature structure is typical of the east coast of India during the northeast monsoon.

Islands. Variations in the temperature gradients occur in the vicinity of islands. This land boundary will act as a barrier, thus resulting in the "piling up" of surface water on the windward side and the "removal" of surface water on the leeward side (Fig. 21). On the northeast, or windward side, of the Hawaiian Islands, for example, the layer depth has been found to be deeper than that on the opposite side.[7]

Basins. Sea water temperatures in a subsurface basin remain relatively constant. However, the water above sill depth may change with tidal or other currents. A sharp temperature gradient may be formed at the sill depth if the water that flows over the sill has a different temperature from that of the basin water (Fig. 22). These gradients may be either positive or negative, depending upon the type of water transported across the basin.

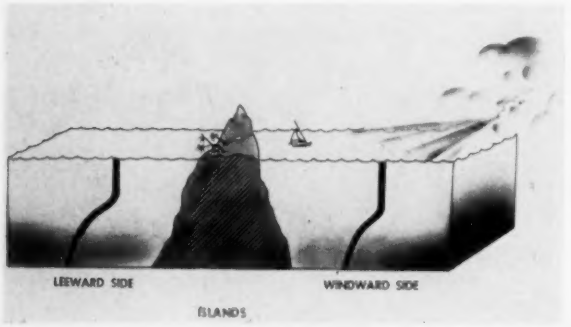

FIG. 21.

Time Cycles of Temperature Structure in the Sea

In addition to internal waves and tidal influences, longer period diurnal and annual cycles occur. Temperature structure here is a periodic function of time. The factors causing these cyclic changes are, however, numerous. Three-hour periods are used for the diurnal temperature cycle diagram. As diurnal heating and cooling are primarily confined to the upper 30 feet, enlargements of this area are shown. The general case illustrated is one in which no residual heat is added to or substracted from the water after the 24-hour diurnal cycle. The periods chosen for a annual cycle are three-month intervals, corresponding to the seasons. For example, winter is taken as early February, spring as early May, summer as early August, and fall as early November. The extreme maximum and minimum values of temperature in winter and summer, respectively, occur a little later in high latitudes than in the low.

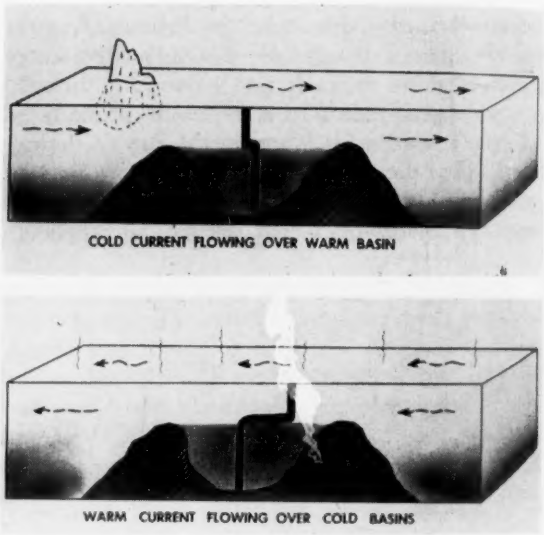

FIG. 22. Basins.

Diurnal Changes. The characteristics of diurnal heating near the surface depend upon the diurnal changes in the factors that lead to the heating of the water. The most pronounced diurnal

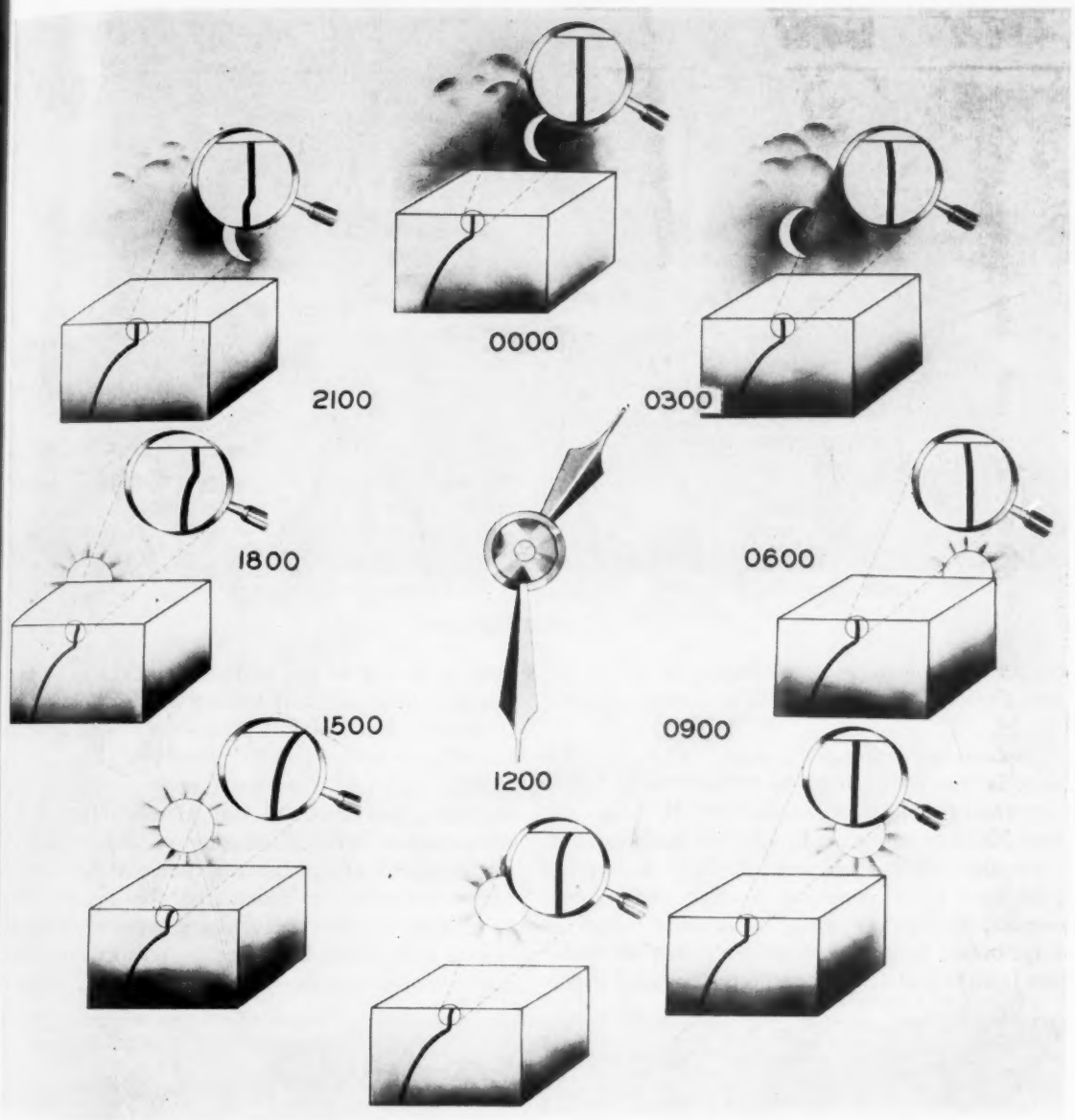

FIG. 23. Diurnal changes.

heating occurs at mid-latitudes during the summer. Here the water is frequently isothermal near the surface at 0000 (midnight) and becomes slightly positive by 0600 in the morning. By 0900 heating has again returned the water to an isothermal condition, by noon negative gradients appear at the surface, and by 1500 the surface heating reaches a maximum. After this time the surface starts to cool, thus resulting in an isothermal layer over a weak negative gradient. The subsurface temperature maximum is reached a few hours after the surface maximum. Cooling continues until by midnight the upper layer is again isothermal (Fig. 23). Variations of this cycle depend upon location, season, and local meteorological conditions. During windy weather, of course, the surface layer becomes mixed and such a cycle cannot occur.

Low-Latitude Seasonal Changes. Throughout the year, in the low latitudes, trade winds maintain a deep surface layer of high-temperature water over a permanent thermocline. Although solar radiation is high, the heated water is carried away by currents as fast as it becomes warm. On the equator in mid-Pacific the sun radiation undergoes a semiannual cycle, with the greatest intensity in the spring and fall. This and probably current variations produce

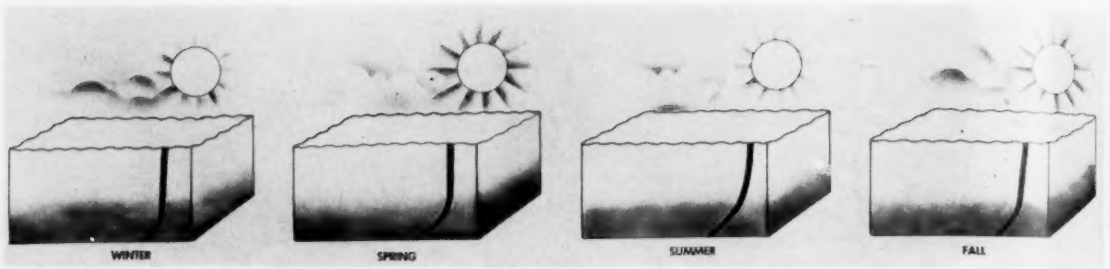

FIG. 24. Low-latitude seasonal changes.

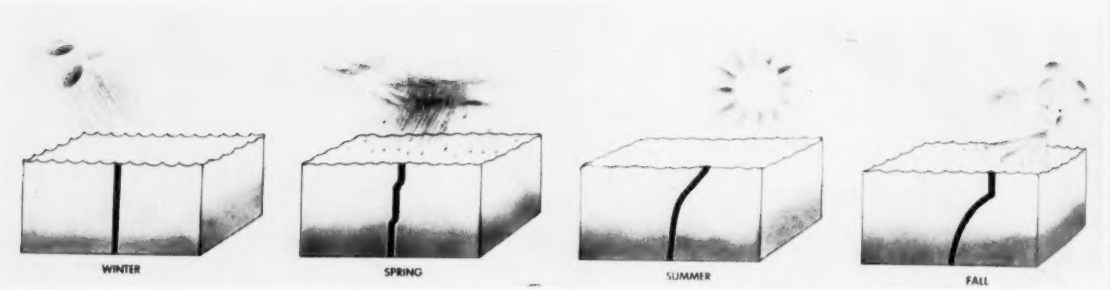

FIG. 25. Mid-latitude seasonal changes.

a deeper layer of warm water shortly after the sun passes through the vernal and autimnal equinox (Fig. 24).[8]

Mid-Latitude Seasonal Changes. The combination of factors controlling the vertical temperature structure in mid-latitude, around 30° N, causes the upper 500 feet of water to become isothermal in winter. By spring small steps develop at varying depths during this period of heating and mixing. However, the deeper water is actually colder in spring, owing to an apparent advection of colder water from below. In summer, large negative gradients occurring at the surface are caused by more heating, diffusion and milder winds. Cooling and increased winds in fall produce the characteristic mixed layer over a sharp thermocline (Fig. 25).[9]

High-Latitude Seasonal Changes. In the high latitudes, just north of the Aleutian Islands, the temperature structure during winter is virtually isothermal to a depth greater than 400 feet. Slightly higher temperatures around 500 feet are attributed to subsurface advection and are believed characteristic of this region. By spring the temperature-depth curve begins to show steps, indicative of successive

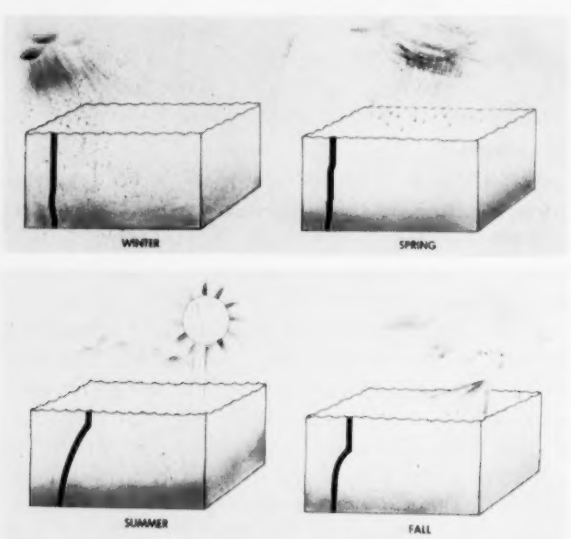

FIG. 26. High-latitude seasonal changes.

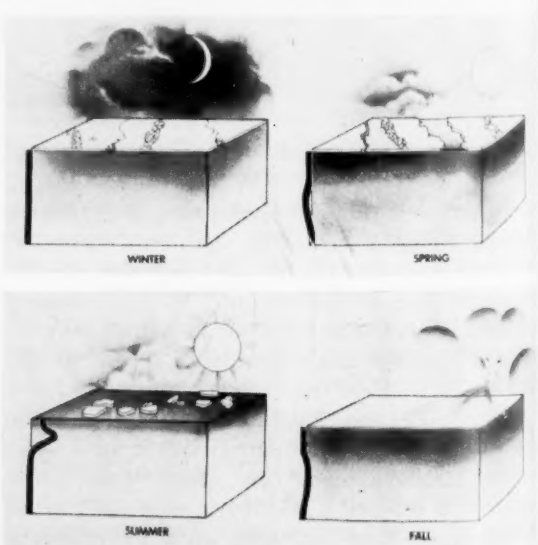

FIG. 27. Arctic seasonal changes.

heating and mixing of the water. By summer these steps become more numerous and, by diffusion, merge into the seasonal thermocline. Owing to frequent winds in this region, the immediate surface layer usually remains isothermal even though heat is being added to the water. In the fall the isothermal layer becomes deeper. This is caused by increased mixing and cooling (Fig. 26).[10]

Arctic Seasonal Changes. In the Arctic, north of the Bering Strait, the surface is covered by ice in winter. The cooled surface water creates vertical convection currents which produce isothermal structures.[11] By spring the ice becomes thicker and the water remains virtually isothermal, although minor gradients are caused by subsurface advection. In the summer the surface layer is heated. In addition, warmer water is advected into the region from the south at a subsurface level, thus creating a subsurface temperature maximum in this region.[11] By fall the surface again freezes and the cooling and mixing processes create an isothermal layer over a slight positive gradient (Fig. 27).

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Reviewed by Robert Gaunt.

The Dakota Heyóka Cult

JAMES H. HOWARD

The author received his B.A and M.A. in anthropology at the University of Nebraska, and is presently working toward a Ph.D. in anthropology at the University of Michigan. In 1951–52, he directed archeological work at the Like-A-Fishhook village site (Old Fort Berthold) in the Garrison Reservoir area, North Dakota, and has done ethnographic work among the Ponca, Dakota and Plains-Ojibwa tribes.

ONE of the most interesting tribal institutions of the Dakota is the cult known as the *heyóka* or *heyóka wozé*. The *heyóka* cult is made up of individuals who, because they have seen the thunder god in a vision, are obliged to assume the role of antinatural clowns. They must, on certain occasions, wear long-nosed masks and ragged clothing and do all things in exactly the opposite of the normal manner. The *heyóka* believe that if they do not perform this humiliating ritual they will be struck by lightning.

The *heyóka* cult is apparently quite old, and may well be the oldest of surviving Dakota ceremonial practices. It is found, in almost exactly the same form, among all bands of the Dakota. Very similar groups occur among the Assiniboin,* the Plains-Ojibwa, and the Plains-Cree, neighbors of the Dakota to the north.[1] These last three tribes share many features of the Dakota cult, such as the use of masks and ragged clothing, connection with the thunder being, contrary behavior, and backward speech. They lack, however, the trick of taking a piece of meat from a kettle of boiling water with the bare hand, which is a characteristic performance of the Dakota cult. The Ponca, neighbors of the Dakota to the south, once had a *heyóka* cult, which they called by that name, but it is now obsolete.[2] As this tribe also had another group of antinatural clowns called *thanígrathà* it seems likely that the *heyóka* cult of the Ponca was a later adoption from the Teton Dakota.[2] Masking, contrary behavior, backward speech, and the boiling water trick were also connected with the Ponca *heyóka* cult. Antinatural clowns, of a generally similar type, are present in many Plains tribes, but lack such specific features of the *heyóka* cult as masking, connection with the thunder being, and the boiling water trick.

The Dakota cult is called *heyóka* after a minor tribal deity of the same name. Neill describes this strange god as appearing in four different guises:

> The first appears like a tall and slender man with two faces, like the Janus of ancient mythology. Apollo-like, he holds a bow in his hand streaked with red lightning, also a rattle of deer claws. The *second* is a little old man with a cocked hat and enormous ears, holding a yellow bow. The *third* a man with a flute suspended from his neck. The *fourth* is invisible and mysterious, and is the gentle zephyr which moves the grass and causes the ripple of the water.[3]

Four manifestations of the god *Heyóka* are also mentioned by Gideon H. Pond, although he does not describe them.[4]

As stated earlier, an individual becomes a *heyóka* by reason of having dreamed of the thunder being. One of the best descriptions of the Dakota concept of this awesome deity is given by Walker, who writes:

> *Wakinyan* is a material god whose substance is visible only when He so wills. His properties are *akan* and antinatural. He abides in His lodge on the top of the mountain at the edge of the world where the Sun goes down to the regions under the world. He is many, but they are as only one; He is shapeless, but has wings with four joints each; He has no feet, yet He has huge talons; He has no head, yet has a huge beak with rows of teeth in it, like the teeth of a wolf; His voice is the thunder clap and rolling clouds; He has an eye and its glance is lightning. In a great cedar tree beside His lodge He has His nest made of dry bones, and in it is an enormous egg from which His young continuously issue. He devours His young and they each become one of His many selves. He had issue by the Rock and it was *Iktomi*, the oldest son of the Rock. He flies through

* The Assiniboin cult is, I believe, of Plains-Ojibwa or Plains-Cree origin. Lowie gives the Assiniboin name of the cult as *Wiⁿtgo'gax watci'bi*.[1] The latter part of the name is Assiniboin and means simply "dance"; Lowie derives the first part, *Wiⁿtgo'gax*, from a Siouan stem meaning "crazy." The similarity of this word to the Plains-Cree *Wihtikokan* and the Plains-Ojibwa *Windigokàn* seems too close, however, to be accounted for by coincidence. Other features of the Assiniboin cult, as described by Lowie, likewise indicate a closer connection with the Plains-Ojibwa and Plains-Cree groups than with the Dakota.

all the domain of the Sky, hidden in a robe of clouds, and if one of mankind sees His substance he is thereby made a *heyoka,* and must ever afterwards speak and act clownishly in an anti-natural manner. Yet, if He so wills, He may appear to mankind in the form of a giant man, and if so, He is then the God, Heyoka. One who looks upon the God, Heyoka, is not thereby made a *heyoka.* The potency of the Winged God cannot be imparted to anything. His functions are to cleanse the world from filth and to fight the Monsters who defile the waters and to cause all increase by growth from the ground.

The acceptable manner of addressing Him is by taunt and vilification, the opposite of the intent of the address. He may be visualized as a bird whose wings have four joints. His symbol is a zigzag red line forked at each end. His *akicita* [messengers or police, JHH] are the dog, swallow, snowbird, night hawk, lizard, frog, and dragon fly, and if either of these is seen in a vision the one to whom it appears is thereby made a heyoka.[5]

The *heyóka* cult itself has been described by a number of writers. Mrs. Eastman writes of it as the "dance to the giant"; this name probably alludes to the giant stature attributed to the god. She uses a description of an eastern Dakota performance of the cult ritual as a dramatic feature in a sentimental love story. Mrs. Eastman describes the dancers as wearing bark hats, huge bark earrings, and skin leggings. The familiar boiling water trick, in which performers dip into a boiling pot to retrieve a bison tongue and splash scalding water on each other's backs, is mentioned.[6]

Lynd, an early missionary to the Eastern Dakota, also writes of the cult.[7] He describes the dancers as being nearly naked but wearing tall conical bark hats and mentions the boiling water act. Lynd's coworker and friend, Samuel Pond, likewise mentions the *heyóka* and their blister defying antics.[8] Riggs also gives a brief description of what he calls the "Ha-yo-ka."[9] He writes that the skin of the performer's hands was deadened with "sheep sorrel" before being thrust into the hot liquid.

J. Owen Dorsey is the first modern ethnographer to describe the cult, although he apparently never saw a performance as he gives few details.[10] He does mention, however, that women, as well as men, occasionally became *heyóka.* Two of the finest accounts of the cult in the literature are Wissler's account for the Teton[11] and Lowie's for the Eastern Dakota.[12] Densmore also describes the Teton cult, and includes accounts of two dreams and the transcriptions of seven *heyóka* songs.[13] The most recent study of the *heyóka* is by Wilson D. Wallis, who became so fascinated with the cult as found among the Canadian Dakota that he devotes over half his monograph on this group to the clowns.[14]

During the years 1950–53, I secured additional information regarding the cult from members of the Yankton, Yanktonai, and Teton bands of the Dakota tribe. The most valuable single source of information was a collection of notes made available by Mrs. Frank Fiske, of Fort Yates, North Dakota. This included an account of the *heyóka* ceremony as performed by the Upper Yanktonai and Teton Dakota approximately 75 years ago, together with the transcription of a Dakota *heyóka* song.* Utilizing this as a framework, a description of the complete *heyóka* rite, no longer performed, was worked out. Amplifications and additions to the Fiske data were supplied by several Dakota informants, chief among whom were John Saul, Fort Thompson, South Dakota; Francis Zahn, Fort Yates, North Dakota; and Raymond Buckley, Fort Yates. Buckley himself is a member of the cult.

The *heyóka* ceremony is initiated by a man who has been instructed to perform it in a dream or vision by the thunder god. The penalty for not doing so is to be struck by lightning. The dreamer prepares a feast at which he gathers about him several other men to assist in the performance. Preferably these men should also be *heyóka,* but is not absolutely necessary. If these assistants do not have masks and other regalia of their own, the leader provides them. The day for the ceremony is set, and a meeting place decided upon.

On the appointed day, usually during the performance of the sun dance or some other village festivity, the leader and his assistants retire to the prearranged meeting place and don their costumes. Mrs. Fiske's notes describe the costume of the *heyóka* as follows: "They knot their hair over the forehead. Then they paint the entire body, including the face and hair, with *mákašàn,* or red earth paint. They paint black streaks zig-zag from the corner of the mouth down the neck and arms. This represents lightning." This costume is undoubtedly a very old style. It will be noted that even the masks, considered an almost essential feature in later times, are missing.

Costumes of a later period generally consisted of a loose shirt and leggings of burlap, very ill-fitting, and a mask made of a dried bison paunch, with horsehair sewed at the top in imitation of human hair. At present cloth masks, with long noses, are used instead. Sometimes huge earrings made from tin can tops are attached to the sides

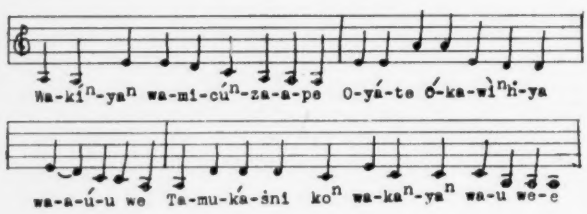
* It is particularly difficult to secure *heyóka* songs since the members of the cult believe that to sing the songs at any other time than during the ceremony is to invite disaster. Mrs. Fiske was only able to secure the song by memorizing it and later transcribing it privately.

of the mask. Common props of the *heyóka* dancer are a crooked bow and arrows, a dummy rifle, a sprig of sage, or a hoop. Less common are rattles of deer hooves and eagle bone whistles.

The leader and others who are to perform the boiling water act rub their hands, arms, backs, and any other part of the body which will come into contact with the boiling water with the juice of one or the other of two plants. The first is *icáhpe hu* or whip root. Gilmore identifies this as *Echinacea augustifolia* D.C. or the narrow leaved purple cone flower.[15] Mrs. Fiske's notes state that the plant is chewed and applied, and that the root is also used for snake bite. The second plant is called *heyóka ta peżúta,* literally "*heyóka* his grass-root." Gilmore identifies this as *Malvastrum coccineum* (Pursh.) A. Gray, or Red False Mallow.[16] Both medicines form a mucilaginous coating on the skin which protects it from the scalding water.

When all of the dancers are ready the group marches in single file from their meeting place in the woods to the center of the camp circle. A fire is built and a large kettle of water is hung over it to boil. The leader then secures a bison tongue, which he holds over the water. Three times he feints with the tongue, as if to drop it into the water. The fourth time, with a weird cry, he drops it in.

The dancers now march to a point slightly north of the pot. Here they form a line and, raising their arms to the sky, sing the following song:

HEYÓKA SONG

A free translation of the text is:

Thunder instructed me to do so; therefore I come and circle the nation; I dreaded to do this but (nevertheless) in a sacred way I come.

The *heyóka* repeat this performance at the west, south, and east of the fire, exactly the opposite of the usual Dakota "sunwise" progression. After praying in each of the four directions they begin to dance about the kettle of water which is now boiling vigorously. They move in a counterclockwise direction, employing bizarre motions and postures and splashing boiling water from the kettle on each other's backs. Finally the leader dances up to the pot and reaches in with his bare arm to retrieve the tongue. While his arm is in the water he shivers and complains of how cold the water is. The tongue is divided among the clowns who eat it, making loud and uncouth noises while doing so. After their feast the clowns dance off into the woods to remove their costumes, thus ending the ceremony.

Present Status of the Cult

At the present time the *heyóka* cult is still present on most Dakota reservations but the full ceremony, as described above, is rarely performed. The clowns now commonly appear in the grass dance, which is the focal point for what is left of aboriginal Dakota culture. On some reservations the cult has degenerated to the point where anyone may act the part of a *heyóka.*

At Little Eagle, South Dakota, in 1947, the author witnessed a pair of *heyóka* who merely acted as buffoons in a grass dance. Their main concern seemed to be scaring small children and aping the other dancers. In addition to the usual long nosed masks and ragged clothing of the *heyóka* each of these clowns had a cardboard sign on his back, one of which read "Batman" and the other "Robin."

The same year, however, at a grass dance held near Cannonball, North Dakota, on the same reservation, two *heyóka* were observed who seemed to be more in the traditional spirit. They danced side by side, raising bunches of sage aloft in prayer-like attitudes at each of the four cardinal points.

The *heyóka* cult on the Standing Rock Reservation, embracing both of the above mentioned communities, still numbers six or seven members. All these persons have had visions of the thunder god instructing them to dance as clowns. There is also one elderly woman who sometimes takes the part of a clown and is thought by the other *heyóka* to have had a thunder vision. Three of the members of the cult in this area are conceded to be subnormal in intelligence. The others, however, appear to be of at least average mentality and one, especially, seems quite intelligent and is more or less a community leader.

Each of these persons appears as a *heyóka* dancer at least once a year, usually at one of the big "outside" pow-wows held in the summer. Sometimes two or three clowns appear at one dance, sometimes only one. The acknowledged "chief" of the cult on this reservation is one of the older mentally deficient individuals. He customarily wears a costume of half white and half blue cloth. Whether this is indicative of his rank as chief of the *heyóka* is not known. All the others wear the usual costume of white cloth masks with long noses and shirts and

leggings of brown burlap. Some have large earrings of tin can tops attached to the sides of their masks.

When not appearing as *heyóka* dancers all but one of the individuals in the cult lead normal lives. The exception, one of the subnormal individuals, apparently takes his role of *heyóka* more seriously. In summer he may be seen wearing a heavy overcoat, rubber overshoes, and a fur cap and mittens. In winter, according to reports, he often wears a straw hat, sandals, and a "T" shirt, and will go forth without a coat in snowstorms.

The woman in this area who is thought to be a *heyóka* danced as a clown at the Fort Yates pow-wow in 1952. She dressed in high heels and a short dress and mocked the behavior of white women. Ordinarily she wears the moccasins and shawl characteristic of the older Indian women on the reservation.

A typical *heyóka* vision was recounted by Raymond Buckley, of Fort Yates, North Dakota, a member of the cult, who stated:

> When I was about ten years old I got real sick. I had a fever and was out of my head a lot of the time. My body hurt all over. One evening about sundown I looked over west. A big thunderhead was rolling up there. I looked in the middle of it and there was *Thunder*. He had a bow and would shoot lightning bolts from it every now and then. He came right down toward me from the thunderhead and said "Don't worry. I am going to make you well again." He told me that when I grew up I would have to dance clown. After that I got better. I didn't dance clown right away. When I was grown up, about age 21, I danced for the first time. I made myself a mask and a costume of gunny sacks and took part. If I hadn't done this, sooner or later I would have been hit by lightning. I dance *heyóka* about once a year, at the pow-wow here in Yates.

The connection with curing in this account is common in the Dakota *heyóka* pattern, but is not an essential element. Curing apparently plays a much more important part in the Plains-Ojibwa, Plains-Cree, and Assiniboin cults.

Summary and Conclusions

The Dakota *heyóka* cult is a specialized northern development of the widespread "contrary" cults of the Plains. Its closest affinities seem to be with the Ponca *heyóka* cult, which was probably a derivative, and the clown cults of the Plains-Ojibwa, Plains-Cree, and Assiniboin. Characteristic features of the Dakota cult are masking, contrary behavior, connection with the thunder being, backward speech, and the trick of extracting meat from a boiling kettle of water with the bare hand. It shares all these features with the now obsolete Ponca *heyóka* cult, and all but the last with the Plains-Ojibwa, Plains-Cree, and Assiniboin clown cults.

Dakota *heyóka* dancers. (Photograph by Frank Fiske, Fort Yates, North Dakota.)

The late Clark Wissler was inclined to connect the *heyóka* cult with the old form of the Pawnee *Irúska*, and with the "hot dance" of certain Northern Plains tribes, all early forms of the modern grass dance.[17] The evidence for this appears to be rather thin. Wissler seems to have based much of his opinion on the faulty phonetic transcriptions of Alanson B. Skinner.[18] Skinner transcribed the word *hethúshka*, which is the Ponca name for the Pawnee *Irúska* or grass dance, as *helocka*. Wissler found this latter rendition very close to the Dakota *heyóka*, and wrote "the similarity to the Pawnee term is obvious."[19] Actually Skinner had mistaken the "th" sound in *Thégiha* (the Omaha and Ponca language) for an "l," and was using the "c" for "sh" a common device in phonetic transcription.

The boiling water trick, which occurred in the old Pawnee *Irúska* and also in the "hot dance" of the Northern Plains, is admittedly a better point for demonstrating the postulated connection. It

should be pointed out, however, that the association of the boiling water trick with the grass dance has a very limited distribution. On the other hand, the boiling water trick itself is quite widespread in North America, and is found in many contexts. It occurs in almost every Plains tribe, and far into the Woodland region. Among the Ojibwa and Plains-Ojibwa it was frequently associated with the *wabáno* ceremony.

At the present time the Dakota *heyóka* cult, although it has degenerated into a mere farce in many areas, is still somewhat sacred in the more conservative reservation communities. Even where it no longer has a sacred significance it still seems to be definitely connected with the "Indian" as opposed to the "White man" way. Perhaps the ability to play the clown in this manner gives certain maladjusted individuals the opportunity to "shine" and mock their tormentors, both Indian and white. The account of the elderly woman imitating the dress and behavior of white women certainly suggests that "dancing clown" provides an outlet for certain frustrations resulting from minority status.

In conclusion the remarks of Walker, quoted by Wissler,[20] concerning the role of the *heyóka* in a Dakota community, seem worth repeating:

> To be a *heyoka woze* (*woze*, to dip out, referring to the boiling water trick) is a misfortune dreaded by all, for such a one is held in light esteem by the people and expected to act the clown at all times. Yet a witty *heyoka woze* may exercise his wit so as to gain the esteem and confidence of the people and become a head man among them.

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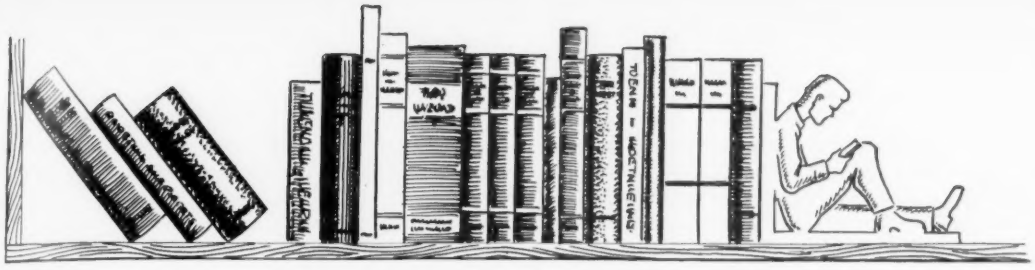

BOOK REVIEWS

Age and Achievement. Harvey C. Lehman. Princeton, N. J.: Princeton Univ. Press, 1953. xi + 359 pp. Illus. $7.50.

If you haven't cut your name on the door of fame by the time you've reached 40, you might just as well put up your jackknife." This comment, ascribed to Oliver Wendell Holmes, Jr., summarizes the essential impact of this book. If you are a forty-year-old scientist and have not yet achieved eminence you still have time to turn to composing musical comedy, or become a college president or a public servant. You have until eighty to be a "Receiver of an Annual Income of $1,000,000," but it is too late to compose outstanding religious hymns.

With the exception of chapters 15 and 20, all chapters are reprints or modifications of separate articles appearing since 1936. The book is divided into five major sections: Age and Achievement; Quality versus Quantity; The Range of the Creative Years; Past, Present, and Future Achievement; General Conclusions.

The basic data are presented in 170 different figures with 61 summary tables showing greater statistical detail. The 231 figures and tables in 331 pages of textual presentation illustrate the mass of data from which the conclusions are drawn. "I have attempted to do just one thing, namely, to set forth the relationship between chronological age and outstanding performances" (p. vii). This book will provide only limited reference material for the wider variety of important problems in geriatrics. Questions of personality dynamics in aging extend well beyond the purpose of the research program reported here and remain as contributions to be made by the reader. If you are interested in anything other than the cold facts of the relation between age and outstanding achievement, look elsewhere. Professor Lehman recognizes the limitations of his data and does not try to "explain" the findings. From time to time, he points out obvious variables essential to accurate interpretation, for example, the different criteria used to measure quality and quantity of output in the several specialized fields of endeavor and allowance for the unequal number of individuals alive at successive age levels. For the most part the book presents results with a minimum account of the methods and procedures used. An independent worker might not be able to replicate the operations on which the present findings are based.

In all of the seventeen different science areas sampled, the peak of highly superior production was reached before the age of forty. In chemistry, before the age of thirty. Because of the gradual decline in productivity (as opposed to its rapid rise), the statistical peak of maximum output is not always a stable point. For example, even a five percent shift in productivity toward the older age period in chemistry would make a significant shift in the form of the graph. The high point of top quality productivity for the following science areas was between the ages of thirty and thirty four: mathematics, physics, electronics, practical inventions, botany, and the classical descriptions of disease. The ten-year span from ages thirty to thirty-nine includes the peak period for: surgical technics, genetics, entomology, and psychology. The following specialties fall in the narrower band of five years, ages thirty-five to thirty-nine: geology, astronomy, bacteriology, physiology, pathology, and medical discoveries. Philosophers produced important works between the ages of twenty-two and eighty, although the most important books occurred at the ages of thirty-five to thirty-nine. Production in the arts and letters shows essentially the same picture, with the best work coming at the early ages.

In the final chapter three summary generalizations are made: "Within any given field of creative endeavor: (1) the maximum production rate for output of highest quality usually occurs at an earlier age than the maximum rate for less distinguished works by the same individuals; (2) the rate of good production usually does not change much in the middle years and the decline, when it comes, is gradual at all the older ages . . . ; (3) production of highest quality tends to fall off not only at an earlier age but also at a more rapid rate than does output of lesser merit . . ." (p. 326).

Only the records of deceased scientists were used, but as a general rule the men born between 1775 and 1850 produced their best work at a younger age than did preceding generations of outstanding scientists and artists. However, the seniority principle seems to be taking a stronger hold in military, political, and religious spheres since the leaders in these fields are older now than in the earlier era.

Throughout the book the author has criterion and sampling troubles. It would be difficult to establish a common yardstick to select an equal proportion of eminent men in diverse areas of human endeavor. Typical of the criteria employed were T. P. Hilditch's *A Concise History of Chemistry,* Cajori's *A History of Mathematics,* Magie's *A Source Book in Physics,* and

Shapley and Howarth's *A Source Book in Astronomy*. Lehman supplemented this type of reference with additional evidence suggested by specialists in the respective science or arts fields. He avoids the error of making decimal point interpretations from data significant to only the first digit.

The pages proceed in an informal conversational style, with sufficient introjection of interpretive "asides" to remind us that the author recognizes the challenge of explanation and the inherent boredom of masses of homogeneous figures and tables. As a contribution to science its value rests with the importance of the central theme: in science, art, music, literature, and philosophy the output of historically significant works (as judged by the author's criteria) reached a peak in the years between thirty and forty years of age.

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The Making of a Scientist. Anne Rol. New York: Dodd, Mead, 1953. ix + 244 pp. $3.75.

SMALL groups of eminent scientists in the fields of anthropology, biology, physics, and psychology were interviewed and given several psychological tests by the author. The purpose of these studies was the discovery of conditions responsible for vocational choice and successful performance in science, and the differences between groups in terms of these conditions and of some characteristics of personality. The book is almost as much an autobiography as it is a report of the studies. The design of the studies and the methods of investigation are not clearly presented, many of the results are given in anecdotal form, and the conclusions are both difficult to relate to the data and to differentiate from the opinions of the author. The problem, however, is one of intrinsic interest to the scientist and of considerable social significance. The reader will find much of interest to him and some information of value. If this book does nothing more than provide a stimulus for further research, it will have served a most useful function.

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The Logic of Modern Science. J. R. Kantor. Bloomington, Ind.: Principia Press, 1953. xvi + 359 pp. $6.00.

ALTHOUGH J. R. Kantor is generally regarded by the psychological fraternity as a behaviorist, he makes for himself a somewhat different classification by coining the phrase interbehavioral psychologist. Long suspicious of anything that smacks in the slightest of the mental or the psychic, he believes that even the behaviorists have not extracted themselves completely from the dualistic tradition. Only interbehavioral psychology is completely naturalistic and objective.

The term interbehavioral for Kantor appears to refer simply to the contacts of individuals with things and events. He admits that his interbehavioral approach may seem oversimplified to many readers. But this apparent oversimplicity, he feels, exists because he has cleared his system of the many pseudoproblems which entered science along with traditional philosophical ideas.

In *The Logic of Modern Science* the author carries the torch for an interbehavioral view of all science. The biologists with their concept of "the living," the physical scientists with their principle of indeterminacy, the social scientists with their mentalistic formulations, and the humanistic scholars with their rather mystical theories all need to clean house, for all are dualistic in some degree. Kantor takes each discipline in turn and describes its history and its turns and twists toward and away from interbehavioral concepts. He attempts to free logic from every form of absolutist and universalistic principle.

This book has sections on the domain of science, the cultural aspects of science, the methods and technics of science, the subdomains of science, and science and civilization. Each section has from one to six chapters. The book ends with a bibliography of over three hundred items.

The Logic of Modern Science continues with the principles earlier enunciated in Kantor's texts in general, physiological and social psychology, in his *An Objective Psychology of Grammar*, and in his *Psychology and Logic*. His latest book has much to offer those of us who are interested in the broader aspects of science.

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Steps in Psychotherapy. John Dollard, Frank Auld, Jr., and Alice Marsden White. Dael Wolfle, Ed. New York: MacMillan, 1953. ix + 222 pp. $3.50.

DURING the past few years a number of books on psychotherapy have appeared, written by clinical psychologists, and this book marks a continuation of this trend. Of unusual interest is the supervision of a psychiatrist in training by a clinical psychologist. The authors of this book apparently feel that psychotherapy of the type described in the book is within the province of the clinical psychologist and the review of the book must be considered on this basis.

In the preface to the book the authors state "Our therapeutic techniques are based on theory advanced by Dollard and Miller. This theory is a blend of a reenforcement learning theory and psychoanalysis, with Freud, so to say, providing the power, and learning theory the precision." The book is addressed to students, teachers, and researchers in the fields of personality adjustment, abnormal psychology, psychotherapy, social work, psychiatry, counseling, and guidance. "We think it also of some pertinence to that circle of intelligent adults who keep up with new things in the science of human personality."

In the first chapter the authors define psychotherapy and describe what they mean by brief psychotherapy,

emphasizing that brief psychotherapy deals with the immediate problems of the patient. There is a brief discussion of the type of patient who will benefit most from this type of therapy. Of particular value in the teaching of psychotherapy is the description of the relationship between the therapist and the patient which the authors describe as the "interactive episode." The interactive episode is used as a means of dividing psychotherapy into "natural units for scientific description."

The need for careful supervision of inexperienced therapists is given proper emphasis. The chapter on supervision in psychotherapy is particularly valuable by virtue of a discussion of many of the problems faced by the inexperienced therapist, as well as the types of errors that he is likely to make. Attention is called to the fact that many people, patients as well as therapists, have facility with the verbiage of psychoanalytic concepts without an adequate understanding of the significance of such nomenclature. The result is a far too literal interpretation or attitude toward both the understanding and application of such concepts.

The therapy of one patient is very carefully described as to the content of interview, the therapist's reaction to material which the patient brought to the interview, and the supervisor's analysis both as to the meaning of the material and the therapist's response. This is an excellent type of training experience for the learning psychotherapist and is the most acceptable method for adequate teaching of psychotherapeutic technics.

The book covers a total of seventeen abstracted interviews. One interview, the eleventh, is quoted in its entirety from the recording made at the time of the interview. A valuable discussion of the dynamics of the patient's problem is presented in the chapter immediately following the record of the interviews, together with some illustrative material excerpted from other patients' records. I do not agree completely with the interpretation of the dynamic material presented.

The author indicates that some projective technics, as, for example, the Rorschach test, are of questionable value. This may be true, but the value of the Rorschach varies with the interpreter and it should always be used in conjunction with other tests as well as with the clinical experience of the therapist. The authors include reports by two psychologists based on test data, one of whom indicated that the test battery was incomplete. The authors make another good point in that the psychological interpretations are not completely objective if the psychologist making the survey of the test procedures is familiar with the history of the patient. Some psychologists feel that the value of their interpretation is enhanced by a knowledge of the patient's background. On the other hand, as the authors point out in this book, under such circumstances the interpretation of the test results must of necessity lose some of its objectivity.

This is a book which is well worth reading and contains much of value. Attention should be called to the fact that it was apparent at the time the patient was accepted for therapy that the therapist might not be able to complete the treatment before other commitments made it important and necessary for him to discontinue therapy. This is not quite fair to the patient, who should be accepted for therapy on completion of the required interviews. To establish relationship with a new therapist may present serious difficulties.

Examined in the frame of reference of a teaching exercise, *Steps in Psychotherapy* has material of interest and value.

RAYMOND W. WAGGONER
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Films in Psychiatry, Psychology and Mental Health. Adolf Nichtenhauser, Marie Coleman, and David Ruhe. New York: Health Education Council, 1953. 269 pp.

THIS unique publication is a result of the need for reliable evaluation of the host of films now available in psychiatry, psychology, and mental health. The authors have brought together a list of one hundred and one films released for showing prior to January, 1953. The study was made by the Medical Audio-Visual Institute of the Association of American Medical Colleges and was supported by funds from several foundations.

The core of the book consists of a series of critical reviews of fifty-one films in the three areas. The body of each review consists of two main parts, namely, a precise description of the content prepared in such a fashion as to reproduce its character and texture, and an excellent appraisal which analyzes the purpose and objectives, the accuracy and scientific significance of the technical content, and reaches conclusions as to what can be learned and how effectively a person can learn from the film. Additional information in each review includes: audience groups for whom the film appears suitable; discussion of materials that accompany the film, such as study guide or film strip; production data, such as running time, and expense involved; and sources from which the films may be obtained.

The usefulness of the book is extended by the subject matter index which provides clues to the actual content of the films. For example, by consulting this index one may find the portrayal of hostility in two films other than the *Feeling of Hostility*. Finally, a graphic guide suggests the appropriateness of each of the fifty-one films for particular audiences.

The limitation of the publication is the small number of detailed reviews in each of the three fields and the too brief annotations of the supplementary list of fifty additional films. Although panels of reviewers which were composed mainly of specialists and teachers in psychiatry and psychology viewed the films, limitation of staff and funds deterred the desirable procedure of securing the response of the appropriate audience group.

The book is a major contribution to professional and popular teaching in health and medical education. It will be of great value to persons in these professions as well as to other groups, namely, to audio-visual

educators for pointing new directions in the evaluation of films, and to producers in promoting higher quality in new films.

EDITH M. LINDSAY

School of Public Health
University of California

Introduction to Electric Theory. R. G. Fowler. Cambridge, Mass.: Addison-Wesley, 1953. xii + 390 pp. Illus. $7.50.

INTRODUCTION TO ELECTRIC THEORY is directed primarily toward the needs of college students of physics at the junior and senior level. With this aim in mind, the author has tailored both his choice of material and the level of its presentation. He has, for instance, successfully avoided the temptation to squeeze a little electronics into an electricity and magnetism course, and he has relegated the materials of circuit theory (other than a necessary early introduction of Kirchhoff's laws) to the last two chapters of the book. His treatment of magnetic media utilizes both the easily visualized magnetic pole approach and the ultimately necessary circulating current concepts.

Throughout the book there is a coordinated and successful build-up of the physical principles of electric and magnetic forces and energy relations, culminating in Chapter 9, "Stress and Energy in [materials in] the Electromagnetic Field." Tensor notation is avoided, but numerous special examples with clear vector drawings bring out the important physical concepts for static electric and magnetic fields. A brief discussion of the Poynting vector and energy relations in changing electromagnetic fields is included.

Addison-Wesley's high standard of textual illustrations is maintained in this book. Indeed, their excellence suggests one minor criticism in the text. Although equations in scalar notation are always paralleled by equations in vector notation, the vector analysis is not developed to the extent desirable in a senior-level course.

The always troublesome questions of units are discussed clearly in the appendix. The possible choices of dimensions for ϵ_0 and μ_0 are mentioned but not stressed. The author's ultimate choice is a rationalized mks system.

The reviewer has had the experience common to many of trying to teach from a "treatise" rather than a textbook. It would be a pleasure to teach from Dr. Fowler's textbook.

WILLIAM V. SMITH

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J. Robert Oppenheimer and the Atomic Story. J. Alvin Kugelmass. New York: Julian Messner, 1953. vii + 179 pp. $2.75.

THE AUTHOR, a newspaperman and journalistic writer, presents to the lay and juvenile reader the story of the development of atomic energy and its implications, weaving into it the genius of J. Robert Oppenheimer, or "Oppy" as he is affectionately referred to throughout the book.

Beginning with a dip into the atmosphere of the Institute of Advanced Studies at Princeton, the manifold duties of the director are contrasted with his wide interests, happy family life, and social activities. The early chapters trace the development of Oppy's genius from his studious but lonely boyhood to the years of brilliant teaching and research at the University of California and the California Institute of Technology. In five pages the history of atomic theory from Democritus to Rutherford is traced, in eleven more, the story of atomic energy from Einstein to uranium fission. The Los Alamos project, the problems of isotope separation, and others lead to a dramatic chapter on the explosion of the first bomb at Alamogordo. The final chapters are concerned with the social and political problems that have arisen from the release of atomic energy. Occasional reference is made to Oppy's contributions in all this, and the account is sprinkled with anecdotes and quotations involving Oppy and other scientists and statesmen.

One can only wish that this interesting story had been written a little more carefully. The use of "nucleuses" for the plural of nucleus makes one wonder whether the author knows better or whether this is merely journalistic license. An unusual picture of the atom is conveyed by the sentence, "Now within the atom there are nuclei, infinitesimal particles, which total about one million multiplied by one million." And to say that a radiation meter "discharge(s) the rays just as does a lightning conductor attached to a house" calls for further explanation. Only a superficial explanation of atomic processes and of Oppy's theoretical contributions is attempted.

To one who has followed the newspaper headlines, there is little new on the atomic story to be found in this book. However, if it reaches some members of the population who will not read more technical works on the subject, it will serve a useful purpose.

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Puritan Sage: Collected Writings of Jonathan Edwards. Vergilius Ferm, Ed. New York: Library Publishers, 1953. xxvii + 640 pp. $7.50.

THIS volume of collected writings has been issued as a tribute to Jonathan Edwards in commemoration of his birth two hundred and fifty years ago (1703). That he deserves this tribute is unquestioned, for he ranks among the leading minds produced by this country.

Edwards lived in a period of transition when the ideas of the Enlightenment were slowly making headway in the New World. The emphasis on scientific inquiry

and on rationalism, two essentials in this development, was reflected in the close observation, the precision, and the careful analysis of Edwards' mind. From his essay entitled "Of Insects," written at the age of eleven, through his notes on "The Mind" and on "Natural Science" these characteristics are apparent. But Edwards acted primarily as a theologian and, more precisely, a strictly Calvinistic one. And there is a certain irony in his use of the tools of the Enlightenment to erect a new fortress for the "conservative" Calvinistic theology which emphasized the omnipotence of God and the insignificance of man, rather than to forward some of the main tenets of the Enlightenment which emphasized the importance of man in the cosmos and spoke confidently of his perpetual improvement.

Whether or not one considers Edwards to be a great prophet of truth or a monument to intellectual tragedy, all recognize the great qualities of his mind. And we must be grateful to Vergilius Ferm for editing, in a splendid fashion, this useful book which makes the furnishings of that mind more accessible. In addition to those essays already mentioned, the readers of this *Journal* will probably find the following most interesting and useful: "Of the Rainbow," "The Insufficiency of Reason," and " A Faithful Narrative of the Surprising Work of God. . . ." But an insight into Edwards' mind would be incomplete without reading some of his work on the nature of God and man's relationship to God.

It is interesting that this book on Edwards should appear at this time. Perceptive observers have noted recently that neo-Calvinistic ideas are receiving a warmer reception now than they have enjoyed in many decades. So this volume is, in a sense, a commentary on our times, when many people, beseiged by the problems of the contemporary scene, see Edwards' degraded and degrading man as being closer to reality than the confident assumption of mankind's progress expressed by the exponents of the Enlightenment.

CLARENCE L. VER STEEG

The College of Liberal Arts
Northwestern University

Conquest of the Moon. Wernher von Braun, Fred L. Whipple, and Willy Ley. New York: Viking Press, 1953. 126 pp. Illus. $4.50.

THIS book developed from a series of articles in *Collier's* magazine under the title, "Man on the Moon." The text has been expanded to about five times its original amount. The material presented is authoritative, but the book can be read with interest and enjoyment, even by one to whom mathematics is an unknown language. Willy Ley is well known for his popular articles and lectures on rockets and space travel. Fred Whipple, an astronomer of Harvard University and author of *Earth, Moon and Planets*, is one of those rare scientists who can talk in simple terms about his special field of research. Wernher von Braun was a rocket specialist for the Germans in World War II and now is chief of the U.S. Army's Guided Missile Laboratory.

Conquest of the Moon presents a plan for a round-trip to the moon by rocket-ship, with some details as to moon-ship, crew, fuel, navigation, and program to be carried out once the moon is reached. The voyage is to be made in two steps. Men and material are to be moved up one thousand seventy-five miles to an artificial satellite circling the earth twelve times a day. Fuel in the form of hydrazine and nitric acid will be used; 170 tons of fuel will be needed to lift each ton to the space-station. There the fuel for the trip to the moon will be left in plastic tanks tied together with nylon cord until the three moon-ships are ready to go. One moon-ship is to carry cargo; the other, two passengers.

One of the most interesting parts of the book is the account of what would happen if one of the moon-ships jumped its proper track in space. The impression is given that the safety of the fifty members of the expedition will depend on the continuous and proper functioning of each of a few thousand vacuum tubes. One hopes that the moon-ship as finally built will have a number of big red push-buttons labeled, "If you don't like what is happening, push this button!" The authors do not even hint that something might be overlooked. One wonders if they know that even on the most carefully planned picnics, the salt is sometimes left at home.

It is possible that the large cost, here probably underestimated at about four and one-half billion dollars, combined with the inherent uncertainty of success, may delay the project for many years, even beyond the turn of the century suggested by the authors. The establishment of an artificial satellite can be undertaken for a fraction of this cost and is a natural first step; the ten years allotted by the authors for this achievement do not seem unreasonable. The possible use of atomic power is dismissed in a single paragraph. Apparently one cannot speculate on the use of hydrogen in a nuclear power plant without running into military restrictions.

The illustrations by Chesley Bonestell, Rolf Klep, and Fred Freeman include eleven large color plates. Here there is some evidence of a lack of close cooperation between the scientists and the artists. For example, on pages 76–77 is a picture of a moon-ship about twenty-four hours after landing on the moon, and the planet Mars is shown well away from the zodiacal light, whereas the plane of revolution of Mars about the sun makes a small angle with the plane of the ecliptic and hence with the zodiacal light. The bright green color of parts of the moon and the amazing cloudless weather of large areas of the earth's surface are typical of the errors often found in this type of illustration. The end-papers show ". . . the space station which is passing 1075 miles above the Hawaiian Islands. . . ." The largest island of the group, Hawaii, can be identified with its point Kalae and Cape Kumukahi which are separated by a known distance of sixty-one nautical miles. The moon shown at the upper right provides an approximate angular scale (say 30 minutes diameter) and any high school student of trigonometry can calculate the distance of the moon-ship above the earth as about two thousand two hundred miles. The reader may wish to try

his hand on the picture on page 11. More than one thousand seventy-five miles? Are we by any chance out of our orbit? Lost? Push that big red button there!

CHARLES H. SMILEY

Ladd Observatory
Brown University

Living With a Disability. Howard A. Rusk and Eugene J. Taylor. New York: Blakiston, 1953. 207 pp. Illus. $3.50.

THE value of this book does not lie in its rhetoric or its verbal presentation. It is a catalogue of self-help devices and advice for handicapped persons. Every handicapped person has devised gadgets to help himself. His physicians, therapists, and friends have contributed their ideas, but nowhere had there been a pooling of these ideas. The authors and their assistants, with help from the National Foundation for Infantile Paralysis and the Disabled Homemakers' Research Fund, gathered information on self-help devices. Those devices which have been proved satisfactory are presented in this book. The book is profusely illustrated. Pictures and diagrams comprise approximately two-thirds of the book. There is a pertinent running commentary explaining the illustrations.

The book begins with an appropriate preamble concerning the type of assistance a handicapped person needs in the process of rehabilitation, directed to the patient, his relatives, and his friends. There follows an Activities of Daily Living test chart which is used to check the patient on how well he can meet the physical demands of daily life. Self-help devices are grouped as: feeding aids; dressing aids; toilet aids; communication aids; transportation aids (including modifications on crutches, wheelchairs, automobiles); kitchen aids, plans and furnishings; recommendations for home design and furnishings, and recreational aids. Preceding the index is a listing of picture credits by number, which gives the name and address of the manufacturer or designer of the self-help device.

OSCAR O. SELKE, JR.

Hermann Hospital
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Disease and Its Conquest. G. T. Hollis. New York: Oxford Univ. Press, 1953. viii + 163 pp. $2.50.

THIS is a popular book written for the layman. The author, who is editor of Oxford Medical Publications, is not a medical man. Yet from his long contact with medicine and his experience in medical editing he writes from an extensive background of knowledge and experience. As he has acquired this without the usual technical training, he unconsciously projects himself into the position of the lay reader who, without a basic foundation in biology, wants to learn something about disease and its control.

The book is a series of thirty-seven unconnected essays of from two to six pages each. The topics cover a wide range within the medical field, from the common infections of childhood to the degenerative diseases of old age, from conditions familiar to every reader in Great Britain or the United States to diseases peculiar to the tropics. In his selection of the disease conditions to be discussed, he has chosen wisely from among those best known to the average reader.

In spite of its title, this is not a book on health. Rather it is a book on disease, an attempt to tell the layman something about the best known diseases in terms that he can understand. Hollis describes the conditions in everyday terminology, and tells what is actually going on within the body and, within limits, what can be done in the way of prevention and treatment. Therapy is stressed as most of the diseases discussed do not fall within the range of preventability.

This is a book that can be recommended with real enthusiasm because of its selection of contents, its readability, and its accuracy.

GAYLORD W. ANDERSON

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University of Minnesota

Managing Your Coronary. William A. Brams. Philadelphia: J. B. Lippincott, 1953. 158 pp. Illus. $2.95.

THIS little book is rather informally written and is somewhat disjointed. For example, there is a section on "The Risk of Excessive Weight" beginning on page 116 and another, entitled "Keep Your Weight Under Control," beginning on page 121, but in between these are sections "What Medicines Do You Need?," "Smoking Is Discouraged," "Tea and Coffee Are Permitted," "Alcoholic Beverages Are Permitted," and "Avoid Constipation." It has the great virtue of stressing the hopeful aspects of coronary disease, but unwittingly it may cause some harm in susceptible patients. This harm may be brought about by excessive detail in the description of some of the pathology of the disease and of electrocardiograms. In general it is an accurate book written in language suitable for lay people. There is, however, one statement on page 48 to the effect that persons with coronary thrombosis have neither the strength nor the desire to sit up. In my experience, more of them prefer to sit up than to lie down, and posture is of some importance in treating the disorder. The book is recommended to those patients who are not too introspective. Such patients should probably not read this or any other material concerning their disease.

EMMET B. BAY

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Elements of Chordate Anatomy. Charles K. Weichert. New York: McGraw-Hill, 1953. vii + 451 pp. Illus. $8.00.

PREPARED for use in undergraduate courses in comparative anatomy, limited to a single semester, this textbook represents a condensation of the

author's larger volume *Anatomy of the Chordates*, a book that is widely used in two-semester courses. The treatment of the subject is along classical lines. Introductory chapters dealing with the characteristics of the chordates, the subdivisions of the phylum Chordata, and the development of the individual lay a foundation for the consideration of the individual organ systems; a single chapter is devoted to each system, and the first to be presented is the integumentary. Descriptions of the digestive, respiratory, excretory, reproductive and endocrine systems follow in that order before consideration is given to the skeleton. The muscular, circulatory, and nervous systems are next presented, and in that order, followed by a chapter on the receptor organs. A final section on characteristics serves to summarize the more important structural peculiarities of subdivisions of the phylum.

Clearly written, well printed, and adequately illustrated, this textbook appears to be admirably suited to meet the present day demands for a course in comparative anatomy limited to one semester. Neverthless, one cannot repress a certain dissatisfaction, not for the book, its style, or its format, but for the demand it is designed to satisfy. Authors and publishers of standard textbooks respond to demand: they cannot be expected to create new approaches to a subject. And it is a new approach or a reappraisal of some of our present day teaching methods and materials in courses in comparative anatomy that is being urged by many, especially those students who elected the course as a part of their premedical training, and they form the larger proportion of the enrollment. Looking back on this course in comparative anatomy, these students too often complain that it was made a testing ground of their memory for apparently unrelated details rather than a course in which they acquired an understanding of morphological principles and terminology; few appear to acquire any appreciation of the view that structure is an important clue to function. The adaptive aspects of structure, although stressed, point out the structural variation without emphasis upon its dynamic consequence. To provide a student with an opportunity to appreciate structure as a theatre of function requires a careful selection of materials, the elimination of superfluous details, and the restriction of examples that few textbooks now reveal. Perhaps the time has come when less prominence will be given to the innumerable variations in the integumentary system, the variations in the vertebrae and the tail fin, and more to the organization of the nervous system, for there are few areas in comparative anatomy so instructive when used as a basis for illustrating adaptation, ontogenetic and phylogenetic principles, and the relationship between structure and function. And there are other areas in which emphasis appears to be misplaced at the expense of the sensory receptors, for example, the vestibulae apparatus and the lateral line system. One final thought—that the difficulty the student has with comparative anatomy is due to the fact that he is rarely given a standard or basis with which to make his comparisons and is obliged to compare each variant in a system with every other. Certainly in those English universities in which comparative anatomy follows human anatomy, and comparisons are made in the light of the latter course, the students appear to derive more from their study than is commonly the case in this country.

D. H. Barron

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Cardano, the Gambling Scholar. Oystein Ore. Princeton, N. J.: Princeton Univ. Press, 1953. xiv + 249 pp. Illus. + plates. $4.00.

In these days when probability and statistical methods are becoming increasingly important in many branches of knowledge, it seems very appropriate to bring to light all historical references and all background material relating to these branches of mathematics. It is particularly noteworthy that Oystein Ore chooses to develop that facet of the personality of Gerolamo Cardano that in most respects is least known and, in essence, the most relevant to a branch of expanding activity in the mathematical sciences.

The colorful life and personality of Gerolamo Cardano has received much attention from many biographers through the ages, for he was one of the most renowned persons of the sixteenth century. Cardano's personal life was marred with almost continual misfortunes. He had a difficult time, in his early development, of overcoming the charge of illegitimacy. His sons brought him grief and disgrace; the eldest son was convicted of murder and executed; and the youngest, a contemptible scoundrel, was eventually banished from Italy. In addition, at an old age he was stripped of his honors and charged with heresy. Lastly, he suffered mental and physical illness during most of his life. Yet his brilliance and imagination as a scholar, combined with a prolific writing ability, gained him due recognition. He published 131 books on mathematics, astronomy, dialectics, death, immortality, water, urine, and music. These are representative of his enormous interests. In medicine, philosophy, and mathematics, he attained the first rank and made contributions carrying over to this very day.

As a physician, before the age of fifty, he was considered second only to Vesalius. In mathematics, the general solution to the cubic algebraic equation is generally credited to him, although in his own mathematical work he acknowledged the value of Tartaglia's work. It was Cardano who refined and was successful in perpetuating the discovery of the solution of the general cubic. The third chapter of this work is devoted to retelling the tragic details of the quarrel between Tartaglia and Cardano over this mathematical discovery. This aspect of the life of Cardano has been reviewed frequently in various biographies, and Ore, in this respect, adds little to the accumulated knowledge on this ridiculous episode.

The novelty and real contribution of this biography

lies in the last two chapters of this book, where Ore studies the gambling pursuits of Cardano and attempts to appraise the mathematical contributions in this connection. Since Cardano was a gambler and a scholar, he collected his observations and analysis of the laws of gambling into an obscure text entitled *Liber de Ludo Aleal* (the book on Games of Chance). It is this book that Ore attempts to decipher and evaluate. This appears to be the first time that significant credit is ascribed to Cardano for having formulated in some vague form a few of the principles and fundamentals of probability theory. Cardano's formulas did give the correct results on dice corresponding to the power laws for repetition of events. He also tabulated many other frequency laws for various games and apparently sensed the concept of expected value which related to the law of large numbers. These are the basic ideas that Ore finds in this writing of Cardano.

In the light of present days where an entire new discipline of mathematical methodology revolving around probabilistic thinking is manifest in all kinds of scholarships, it seems worth while and deserving that Oystein Ore sheds new historical light on the origins of these ideas in mathematics.

SAMUEL KARLIN

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Contributions to the Theory of Games, Vol. II. H. Kuhn and A. W. Tucker, Eds. Princeton, N. J.: Princeton Univ. Press, 1953. viii + 395 pp. Illus. $4.00.

IN the year 1945, the *Theory of Games and Economic Behavior* by John von Neumann and Oskar Morgenstern appeared on the scene. It has been regarded as one of the major scientific achievements of the first half of the twentieth century. This represents a first attempt to define rational optimal behavior for two or more antagonists where a known utility or pay-off function is available to both players.

Many applications of this theory to various branches of knowledge have been found; notably to economics, military tactics, and statistics. Several new theories and mathematical models in the social sciences have been established as a direct consequence of the methodology and philosophy of these endeavors. For example, the theory of linear programming which analyzes several kinds of economic models has been shown to be equivalent to the discrete theory of two-person zero sum games. The entire development in mathematical statistics of decision theory due to Abraham Wald is closely related to the minmax theorem of the theory of games. Most operations research problems employ a method of reasoning similar to that developed in the theory of games. Numerous other examples can be cited.

This monumental work has stimulated vigorous research from many mathematicians who have developed and expanded the theory far beyond its original conception. This present volume represents cumulative efforts in that direction and constitutes a sequel to *Contributions to the Theory of Games*, Vol. I. It contains a collection of twenty-one research articles divided into four main groupings, each shedding light on various aspects to the theory. Part I deals with contributions to the theory of finite zero sum two-person games. Most of the research is concentrated on determining improved methods of computing optimal strategies (procedures of action). A few isolated papers in this section treat some special problems as, for example, the optimal assignment problem and some poker variants. The assignment problem calls for the assignment of n persons to n jobs in such a way as to maximize the total value of the assignment. Similar interesting descriptions can be given for the other models examined.

Part II treats two-person games where each contestant has available an infinite set of basic strategies. Several research articles completely analyze action games where the payoff depends on which player acts first. These afford extremely valuable results with applications, for instance, to military tactical problems. The mathematical complexities of similar types of infinite games are exposed by some pathological examples which make it appear that the research in this direction is still in an incomplete form.

The theory of the extensive form of a game is developed in Part III and some contributions to the theory of n-person games are made in Part IV. As yet no satisfactory basis exists for playing a game involving more than two contestants. The papers of the last section constitute some minor attempts to set up criteria in guiding optimal rational behavior for such general n-person games. The authors hope to throw light on known problems and to lead the reader into new approaches to the general theory.

The present volume thus represents substantial progress and research in enlarging our knowledge of game theory and its applications. It is an absolute necessity in the library of any applied mathematician concerned with the theory of optimal decision making.

SAMUEL KARLIN

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LETTERS

THE EDUCATORS' DEBATE

THIS WRITER, who had seen in advance the paper, "Aimlessness in Education" by Arthur E. Bestor, Jr., protested its publication in *The Scientific Monthly* on the grounds that it lacked accuracy and that it was unscientific in spirit. However, the article was published [*The Scientific Monthly* **75**, 109 (1952)] and was later followed by a book by Bestor, *Educational Wastelands* (Univ. of Illinois Press, 1953). The manuscripts were written in a persuasive style and appeared convincing to those who were not familiar with the sources. If any of the readers of *The Scientific Monthly* are interested in seeing the evidence of Bestor's inaccuracies, it is suggested that they consult "Mr. Bestor in the Land of the Philistines" (*Progressive Education*, January, 1954) and "A Scholar's Documentation" (*Educational Theory*, January, 1954). The first article is by Burnett and the second is by Hand.

D. A. WORCESTER

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"TEAYS RIVER" OR "CONTINENTAL RIVER"

THE STORY of the ancient Teays River, as told by Raymond E. Janssen [*The Scientific Monthly* **77**, 306 (1953)] is astonishing. Here before our eyes we see one of nature's greatest marvels—now that it has been illuminated by the light of science.

With all due respect for W. G. Tight, who discovered and named the Teays Valley, I, for one, protest the name "Teays River." Are we to accept this name, taken from an insignificant "crossroad station" in West Virginia, for the name of a gigantic river that for millions of years "dominated the drainage of preglacial interior America," and still flows beneath the country now known as the United States of America?

Surely some more meaningful name can be proposed. Why not "Continental River?"

JEROME FEE

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MR. FEE'S SUGGESTION is quite interesting and would have merit if there were need for a geographical name of an existing river. However, the river, as an entity, no longer exists, and its residual portions already have their own names. The name is solely of scientific significance for precise identification, like the names of rock formations, plants, and animals. In scientific circles, it is customary for the discoverer of a new species, a new mineral, a former landmass, lake, sea, or river, to apply a name of his choosing, as long as the name has not already been used for a similar application. Once a name has been applied and become recognized by usage in the literature, changing of it fosters confusion, and is therefore seldom acceptable. The mere fact that a selected name may later seem inappropriate is not a valid reason for changing it.

The name Teays, as applied to the great valley and the river that formed it, has been used by geologists for half a century, but only recently are others beginning to hear of it. If the former existence of the great river catches the popular fancy, its name too will become famous like any other great thing that had a humble or unknown beginning.

RAYMOND E. JANSSEN

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Huntington, West Virginia

ESPERANTO VERSUS INTERLINGUA

I WISH to protest against deviation from fact in an article "The Case for Interlingua," in *The Scientific Monthly*, August, 1953, of which I have just seen a reprint.

In this article, Esperanto is brushed off with the implication that it belongs in past history, and the actual statement that it "failed." None of this is true, as anyone who looks up the present status of Esperanto knows very well indeed. Enough people already make use of it to find it worth their while, even if the number of Esperantists should not increase from this day on.

Now we are asked to discard Esperanto and try a new linguistic project that is illustrated by only a textbook, a dictionary, a couple of starting small periodicals, and a few pamphlets—all backed by one local organization and apparently written by the same individuals. We are told, as I see by its pamphlets, that it is for persons "on the doctoral level," and can be read at sight by those who know French, Spanish, or other Romance tongues. But of course the men and women on that level, or struggling toward it, are required to have a working knowledge of French, German, and perhaps other languages. What is the use to them of a project, not in real use, which is just that same old Spanish with a few irregularities cut off and a few foreign words added? Why not stick to Esperanto, which has been proved useful not only on scientific and technical levels but also on lower levels, clear down to one and another "laborista grupo" in European countries?

Esperanto can not be read absolutely "on sight" except by expert linguists, easy as it is. I had to study it a while to get somewhere with it; but I have been well repaid through my professional use of it, translations and original work in it that I have enjoyed reading social contacts that I have made through correspondence and directly. I am glad to know, too, that its history is clean. Cynics have smiled at calling a certain charming song "the Esperantist hymn," and speaking of the lan-

guage as "la kara lingvo," as especially the earlier enthusiasts did. But a little sentimentality, together with surprising actual financial sacrifice, is a better recommendation for this interlanguage than a practice of intrigue, misrepresentation, and other dubious practices which have not been unknown among those who for personal purposes have from time to time wished to wreck it and have tried to "divide and conquer."

A lawyer friend has told me that there is a maxim of equity that is still adhered to which says, "He who comes into court must do so with clean hands." I am glad indeed that the Esperanto interlanguage can do this. Quite earnestly, almost sentimentally, I say, "Vivu Esperanto!"

ELSIE YUNGHANS

25 Forest Avenue
Verona, New Jersey

IF Miss Yunghans were not fairly emphatic about it, I would never have guessed that her letter concerned my article, "The Case for Interlingua." Readers who wish to refer to it but cannot readily lay hands on *The Scientific Monthly* for August, 1953, may obtain reprints from the Interlingua Division of Science Service, 80 East 11th St., New York 3.

ALEXANDER GODE

Science Service
Division De Interlingua
80 East Eleventh Street
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LYCOPODIUM *IS* USEFUL

READING on page 294 of the December issue the commentary on the excellent cover photograph, I was surprised to see the following: "The delicate plants of the genus *Lycopodium* . . . have no economic usefulness to man save this one, that, although flowerless, they appeal to us and delight us with their simple grace and beauty, like their fairly near relatives, the ferns." My surprise stemmed from the words "no economic usefulness to man save this one."

Curiously, even my dictionary fails to mention the use of lycopodium powder which had occurred to me, namely, a foundry parting agent; but *Webster's New International Dictionary*, in defining "lycopodium powder" does state: "a fine yellowish powder composed of the spores of various species of *Lycopodium*, esp. of *L. clavatum*. It is highly inflammable, and is used in the manufacture of fireworks and the artificial representation of lightning; also in medicine as an absorbent in excoriations of the skin and as a coating for pills."

Many men, of course, are not familiar with foundry operations, but it was natural for me to think of the foundry application immediately, since before turning to the rather precarious existence of a free-lance writer I headed the research and control laboratory of The Hill and Griffith Company, one of the leading foundry supply houses.

Lycopodium powder falls into the general class of products known as dry parting compounds. Such products are used by dusting them on the pattern to prevent the mold from sticking and to allow the pattern to be drawn freely from the mold. To the molder employed in ornamental casting work, lycopodium is a common term, although today most foundries have turned to dry parting compounds to the cheaper varieties which usually consist of waterproofed minerals.

Permit me to quote from two of Hill and Griffith's catalogs. From an early one: "Lycopodium is a fine yellow powder, obtained from a plant known as club moss, cultivated in Russia. It is very inflammable. Lycopodium is regarded the world over as a perfect parting and facing, but owing to extreme cost of its collection, shipping and custom duties, the price has almost prohibited its use." And from a recent catalog: "Lycopodium Powder.—The natural parting from Gnydia acknowledged to be unsurpassed for ornamental and nameplate castings. Relatively expensive, but very light and fluffy."

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By P. M. WOODWARD, Principal Scientific Officer, Telecommunications Research Establishment, Ministry of Supply, Malvern, England. 138 pages, $4.50

This book explains in easy stages how the theory of probability applies to electronics, communication, and particularly radar. It was prepared for the reader with no highly-advanced mathematical knowledge who is interested in linking his practical "intuition" with precise mathematical theory.

PHYSICS AND APPLICATION OF SECONDARY ELECTRON EMISSION

By H. BRUINING, Philips Research Laboratories, Eindhoven, Netherlands. 170 pages, $5.00

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New Books Received

Sergei N. Winogradsky: His Life and Work. Selman A. Waksman. New Brunswick, N. J.: Rutgers Univ. Press, 1953. xiii + 150 pp. + plates. $4.00.

Wildlife in Alaska. An ecological reconnaissance. A. Starker Leopold and F. Fraser Darling. New York: Ronald, 1953. ix + 129 pp. Illus. + plates + maps. $2.75.

The Unique Influence of the Johns Hopkins University on American Medicine. Richard H. Shryock. Copenhagen, Denmark: Ejnar Munksgaard, 1953. 77 pp. Dan. kr. 14.; bound: 17.50.

The Zoological Record, Vol. 88. Records of Zoological Literature Relating Chiefly to the Year 1951. G. Burder Stratton, Ed. London: Zoological Society, 1953. v + 19 sections. Paperbound sections at various prices.

Temperature Measurement in Engineering, Vol. I. H. Dean Baker, E. A. Ryder, and N. H. Baker. New York: Wiley; London: Chapman & Hall, 1953. vi + 179 pp. Illus. $3.75.

Surgery of the Biliary Tract, Pancreas & Spleen. Charles B. Puestow. Chicago, Ill.: Year Book, 1953. 370 pp. Illus. $9.00.

Semimicro Qualitative Analysis. Rev. ed. Hervey Hubbard Barber and T. Ivan Taylor. New York: Harper, 1953. xi + 404 pp. Illus. $4.50.

Resources and the American Dream. Including a theory of the limit of growth. Samuel H. Ordway, Jr. New York: Ronald, 1953. vii + 55 pp. $2.00.

Professional People in England. Roy Lewis and Angus Maude. Cambridge, Mass.: Harvard Univ. Press, 1953. vii + 284 pp. $4.00.

Practical Methods in Biochemistry. 6th ed. Frederick C. Koch and Martin E. Hanke. Baltimore, Md.: Williams & Wilkins, 1953. ix + 537 pp. Illus. $5.00.

Plane Trigonometry. Paul R. Rider. Reprint in part from *First-Year Mathematics for Colleges.* New York: Macmillan, 1953. viii + 180 pp. Illus. $3.00.

Linear Operators. Richard G. Cooke. New York: St. Martin's Press, 1953. xii + 454 pp. $10.00.

The Monkey Book. Ernest P. Walker. New York: Macmillan, 1954. 153 pp. Illus. $6.50.

Organic Chemistry. A brief course. Robert Ward Getchell. New York: McGraw-Hill, 1954. viii + 278 pp. $4.00.

Silicified Middle Ordovician Trilobites. H. B. Whittington and W. R. Evitt, II. New York: Geological Society of America, 1953. 137 pp. Illus. + plates.

Educational Psychology. Lee J. Cronbach. New York: Harcourt, Brace, 1954. xxvii + 628 pp. Illus.

Leaders in American Science, Vol. I, 1953–54. Robert C. Cook, Ed. Nashville, Tenn.: Who's Who in American Education, Inc., 1953. 703 pp. Illus. $12.00.

Music Therapy. Edward Podolsky, Ed. New York: Philosophical Library, 1954. xii + 335 pp. Illus. $6.00.

Quantitative Organic Analysis via Functional Groups. 2nd ed. Sidney Siggia. New York: Wiley; London: Chapman & Hall, 1954. x + 227 pp. Illus. $5.00.

What Price Israel. Alfred M. Lilienthal. Chicago: Regnery, 1953. viii + 274 pp. $3.95.

Climatic Change. Evidence, causes, and effects. Harlow Shapley, Ed. Cambridge, Mass.: Harvard Univ. Press, 1953. xii + 318 pp. Illus. $6.00.

The Atomic Submarine and Admiral Rickover. Clay Blair, Jr. New York: Henry Holt, 1954. viii + 277 pp. Plates. $3.50.

Biologia Generale. Emanuele Pàdoa. Torino, Italy: Edizioni Scientifiche Einaudi, 1953. 707 pp. Illus. L. 8000

A Brief Survey of Modern Algebra. Garrett Birkhoff and Saunders Mac Lane. A shorter version of *A Survey of Modern Algebra,* Revised Edition. New York: Macmillan, 1953. viii + 276 pp. Illus. $4.75.

The Collected Papers of Otto Fenichel. First series. Hanna Fenichel and David Rapaport, Eds. New York: Norton, 1953. xiii + 408 pp. $6.50.

Electrical Methods of Blood-Pressure Recording. Frank W. Noble. Springfield, Ill.: Thomas, 1953. vii + 56 pp. Illus. $3.00.

Experimental College Physics. A laboratory manual. 3rd ed. Marsh W. White and Kenneth V. Manning. New York: McGraw-Hill, 1954. xii + 347 pp. Illus. $5.00

Highway Research Board: Proceedings of the Thirty-Second Annual Meeting, Vol. 32 National Academy of Sciences—National Research Council Pub. 271. Fred Burggraf and Walter J. Miller, Eds. Washington, D.C.: Highway Research Board, NRC, 1953. xxi + 616 pp. Illus. $8.50.

Magnetic Amplifiers. George M. Ettinger. London: Methuen; New York: Wiley, 1953. viii + 88 pp. Illus. $1.50.

A Manual of Australian Soils. C. G. Stephens. Melbourne, Australia: Commonwealth Scientific and Industrial Research Organization, 1953. 48 pp. + plates. 25 s.

Great Systems of Yoga. Ernest Wood. New York: Philosophical Library, 1954. xviii + 168 pp. $3.50.

Dimensional Methods and Their Applications. C. M. Focken. New York: St. Martin's Press, 1953. viii + 224 pp. $6.00.

Jaarboek, 1952–1953. Koninklijke Nederlandse Akademie van Wetenschappen. Amsterdam: Noord-Hollandsche Uitgevers, 1953. 347 pp. Illus. + plates.

Culture and Diseases of Game Fishes. H. S. Davis. Berkeley—Los Angeles, Calif.: Univ. of California Press, 1953. x + 332 pp. Illus. $5.00.

The Dawn of the Post-Modern Era: Dimensions of human life in the last half of the twentieth century. Elwyn Judson Trueblood. New York: Philosophical Library, 1954. xii + 198 pp. $3.75.

Introduction to Chemistry. R. T. Sanderson. New York: Wiley; London: Chapman & Hall, 1954. x + 542 pp. Illus. $5.50.

The Size and Growth of Tissue Cells. Joseph G. Hoffman. Springfield, Ill.: Thomas, 1953. xv + 102 pp. Illus. $4.00.

Evolution: Die Geschichte ihrer probleme und Erkenntnisse. Walter Zimmerman. Freiburg-München, Germany: Verlag Karl Alber, 1953. ix + 623 pp. Illus. + plates. DM 32.

Chemical Methods in Industrial Hygiene. Frederick H. Goldman and Morris B. Jacobs. New York: Interscience, 1953. ix + 274 pp. Illus. $3.75.

Vegetation and Watershed Management. E. A. Colman. New York: Ronald Press, 1953. xv + 412 pp. Plates + maps. $7.00.

Vegetable and Flower Seed Production. Leslie R. Hawthorn and Leonard H. Pollard. New York: Blakiston, 1954. xiii + 626 pp. Illus. $7.50.

The Hand-Produced Book. David Diringer. New York: Philosophical Library, 1953. 603 pp. Illus. $15.00.

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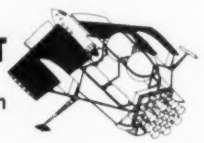

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Meetings

April

15–17. Assoc. of Southeastern Biologists, annual, Baton Rouge, La. (M. A. Gaulden, Oak Ridge, Tenn.)

16. Seismological Soc. of America, annual, Seattle, Wash. (P. Byerly, 208 Bacon Hall, Univ. of California, Berkeley 4.)

16–17. Histochemical Soc., Atlantic City, N.J. (R. D. Lillie, National Institutes of Health, Bethesda, Md.)

18–22. American Assoc. for the Advancement of Science, Southwestern Division, Lubbock, Tex. (F. E. E. Germann, Dept. of Chemistry, Univ. of Colorado, Boulder.)

18–23. American Ceramic Soc., 56th annual, Chicago, Ill. (C. S. Pearce, 3727 Olentangy Blvd., Columbus 2, Ohio.)

19–20. Symposium on the Automatic Production of Electronic Equipment, San Francisco, Calif. (L. K. Lee, Engineering Div., Stanford Research Institute, Stanford, Calif.)

21–23. Southern Industrial Wastes Conf., Houston, Tex. (E. K. Hunt, American Cyanamid Co., Bound Brook, N. J.)

21–24. Cong. of la Sociedad de Internos y Becarios del Instituto Nacional de Cardiologia de Mexico, 2nd, Acapulco, Mex. (J. S. Acevedo, Avenida Cuauhtemoc 300, Mexico, D. F.)

21–24. International Conf. on Electro-Deposition and Metal Finishing, 4th, London, Eng. (Institute of Metal Finishing, 32 Great Ormond St., London, W.C. 1.)

21–27. International Cong. of Prehistoric and Protohistoric Sciences, Madrid, Spain. (A. Beltran-Martinez, University, Zaragoza, Spain.)

21–28. International Cong. of Military Medicine and Pharmacy, 14th, Buenos Aires, Argentina. (Direcion General de Sanidad Militar, Pozos 2045, Buenos Aires.)

22. Conf. on Instrumentation in Water, Sewage, and Industrial Waste Treatment, New York, N. Y. (Brother J. McCabe, Civil Engineering Dept., Manhattan College, New York 71.)

23–24. Montana Acad. of Sciences, Missoula, Mont. (L. H. Harvey, Dept. of Botany, Montana State Univ., Missoula.)

24–9. Liége International Fair, Liége, Belgium. (F. Campus, University of Liége.)

26–28. Metal Powder Show, Chicago, Ill. (Metal Powder Assoc. 420 Lexington Ave., New York 17, N. Y.)

26–28. National Acad. of Sciences, annual, Washington, D.C. (Office of the Home Secretary, National Academy of Sciences, 2101 Constitution Ave., Washington, D.C.)

26–30. American Soc. of Tool Engineers Industrial Exposition, 9th biennial, Philadelphia, Pa. (H. E. Conrad, 10700 Puritan, Detroit 21, Mich.)

26–2. Cong. of the International College of Surgeons, 9th biennial, São Paulo, Brazil. (Secretariat, International College of Surgeons, 1516 Lake Shore Dr., Chicago 10, Ill.)

27–30. International Health Cong., Scarborough, Eng. (P. A. Wells, 90 Buckingham Palace Rd., London, S.W. 1, Eng.)

29–30. Eastern States Health Education Conf., New York, N. Y. (I. Galdston, 2 E. 103 St., New York 29.)

29–30. Symposium of Recent Advances in the Study of Venereal Diseases, 6th annual, Washington, D. C. (J. K. Shafer, Public Health Service Division of Venereal Diseases, Washington 25, D. C.)

29–1. American Mathematical Soc., Chicago, Ill. (J. W. T. Youngs, Univ. of Indiana, Bloomington.)

29–1. American Physical Soc., Washington, D. C. (K. K. Darrow, Columbia Univ., New York 27, N. Y.)

29–1. Kansas Acad. of Science, annual, Hays, Kansas. (C. T. Rogerson, Dept. of Botany, Kansas State College, Manhattan.)

29–1. Midwestern Psychological Assoc., Columbus, Ohio. (L. J. Cronbach, 1007 S. Wright, Champaign, Ill.)

30–1. South Dakota Acad. of Science, annual, Rapid City, S. Dak. (A. L. Haines, Chemistry Dept., Univ. of South Dakota, Vermillion.)

May

2–6. Electrochemical Soc., spring, Chicago, Ill. (H. B. Linford, Columbia Univ., New York 27.)

2–7. Soc. of American Bacteriologists, annual, Pittsburgh, Pa. (F. S. Cheever, P.O. Box 1912, Pittsburgh 30.)

3–5. American Geophysical Union, 35th annual, Washington, D.C. (J. Adkins, Office of Naval Research, Washington 25.)

3–6. Air Pollution Control Assoc., Chattanooga, Tenn. (H. C. Ballman, 4400 5 Ave., Pittsburgh 13, Pa.)

3–6. International Scientific Radio Union (USA National Comm.) and Inst. of Radio Engineers (PGMTT), Washington, D. C. (W. E. Gordon, School of Electrical Engineering, Cornell Univ., Ithaca, N. Y.

3–7. American Psychiatric Assoc., annual, St. Louis, Mo. (R. F. Gayle, Jr., Professional Bldg., Richmond 19, Va.)

3–7. Soc. of Motion Picture and Television Engineers, semiannual, Washington, D.C. (Sec., 342 Madison Ave., New York 17.)

3–8. International Conf. on Complete Gasification of Coal, Liége, Belgium. (J. Venter, 7 Blvd. Frere-Orban, Liége.)

4. World Health Assembly, 7th, Geneva, Switzerland. (WHO, Palais des Nations, Geneva.)

4–6. Electronic Components Symposium, Washington, D.C. (F. B. Haynes, Glenn L. Martin Co., Baltimore 3, Md.)

5–7. American Inst. of Electrical Engineers, north eastern district, Schenectady, N.Y. (H. H. Henline, 33 W. 39 St., New York 8.)

5–7. Forest Products Research Soc., annual, Grand Rapids, Mich. (F. J. Rovsek, Box 2010, University Station, Madison 5, Wis.)

5–8. National Conf. on Health in Colleges, 4th, New York, N.Y. (Sec., American College Health Assoc., 1790 Broadway, New York 19.)

6–8. American Philosophical Assoc., Urbana, Ill. (M. C. Nahm, Bryn Mawr College, Bryn Mawr, Pa.)

7–8. Illinois State Academy of Science, Monmouth, Ill. (L. W. Finley Monmouth College, Monmouth.)

7–8. North Carolina Academy of Science, Greenville, N.C. (J. A. Yarbrough, Meredith College, Raleigh, N.C.)

8–9. Population Assoc. of America, annual, Charlottesville, Va. (H. Carter, c/o National Office of Vital Statistics, Dept. of Health, Education and Welfare, Washington 25, D.C.)

8–16. International Cong. of Thalassotherapy, Dubrovnik, Yugoslavia. (C. Plavsic, Zeleni Venac 1, Belgrade, Yugoslavia.)